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TRANSFER OF MILITARY TECHNOLOGY
TO DEVELOPING COUNTRIES:
THE TURKISH CASE

by

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June 1989

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Transfer of Military Technology
to Developing Countries:
The Turkish Case

by

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ABSTRACT

There is a switch from direct arms sales to military technology transfer to produce arms in the name of self-sufficiency. The value of domestic arms production at the beginning of the 1980s was about 500 times higher than that at the beginning of the 1950s. By the early 1980s, more than 50 developing countries were producing weapons. The evidence indicates that Turkey has relatively enough arms production potential. However, there is a technological gap which needs to be closed. Turkey should first follow a "path strategy" to create minimum required technological base by using some form of military technology transfer. Then, in the efforts toward indigenous arms production "engineering strategy" may be applied.

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TABLE OF ABBREVIATIONS

AOI	Arab Organization of Industrialization
COCOM	Coordinating Committee for Multilateral Export Controls
DIDA	Defense Development and Support Administration
FMS	Foreign Military Sales
FR	France
FRG	Federal Republic of Germany
GNP	Gross National Product
ISIC	International Standard Industrial Classification
lb	Pound
m	meter
MKEK	General Directorate of Mechanical and Chemical Industries
PAPB	Potential Arms Production Base
PDC	Potential Defense Capacity
PGM	Precision Guided Munitions
SIPRI	Stockholm International Peace Research Institute
UK	United Kingdom
UN	United Nations
USA	United States of America
USSR	Soviet Union

I. INTRODUCTION

The developments in military technology are so fast that even some developed countries cannot afford to keep pace. Therefore, technological dependence arises mainly from the gap of technical knowledge and skill between supplier and recipient nations. Developing countries seek to transfer military technology to create and expand their technologically oriented armed forces.

A. DEFINITION

The two segments of the term "military technology transfer" may be defined as follows:

Military technology is the understanding and application of specific knowledge, technical information, know-how, critical materials, unique manufacturing equipment, end products and test equipment essential to research, development and production of weapons systems[1], comprising weapon platform

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[1]Louscher and Salomone (1987, pp. 13-14) group twenty-seven different major weapons systems into air, ground, sea and missile/radar categories. Among the major air weapons include in the typology are trainers, fighters, helicopters, light planes, transport aircraft, and counter-insurgency aircraft. Major ground weapons include armored personnel carriers, light tanks, medium tanks, armored cars, artillery, infantry combat vehicles, and self-propelled howitzers. Fast attack craft, frigates, patrol craft, submarines, coastal patrol boats, fast patrol boats, destroyers,

(e.g., a ship, aircraft, or armored vehicle), weapons (e.g., gun, missile or torpedo), and means of command and control (Roberts, 1988, p. 25). Figure 1 indicates that military technology can be in the form of physical deliverables, show-how, and information.

Transfer is the flow of military technology from a country, other than that from which this technology originates, to another country. (Ezegbobelu, 1986, p. 9)

It is possible to distinguish arms and process transfer. Arms transfer entails the import of weapons and weapons systems embodying new technology that have few or no indigenous substitutes. A process transfer, though, entails the import of know-how necessary for indigenous production of needed arms. (Louscher and Salomone, 1987, p. 3)

The production of the Lockheed F-104 fighter's in European countries may give a general idea about what technology transfer includes. Its production required the following technology transfers besides the supply of major components and subsystems (Brzoska and others, 1980, p. 38):

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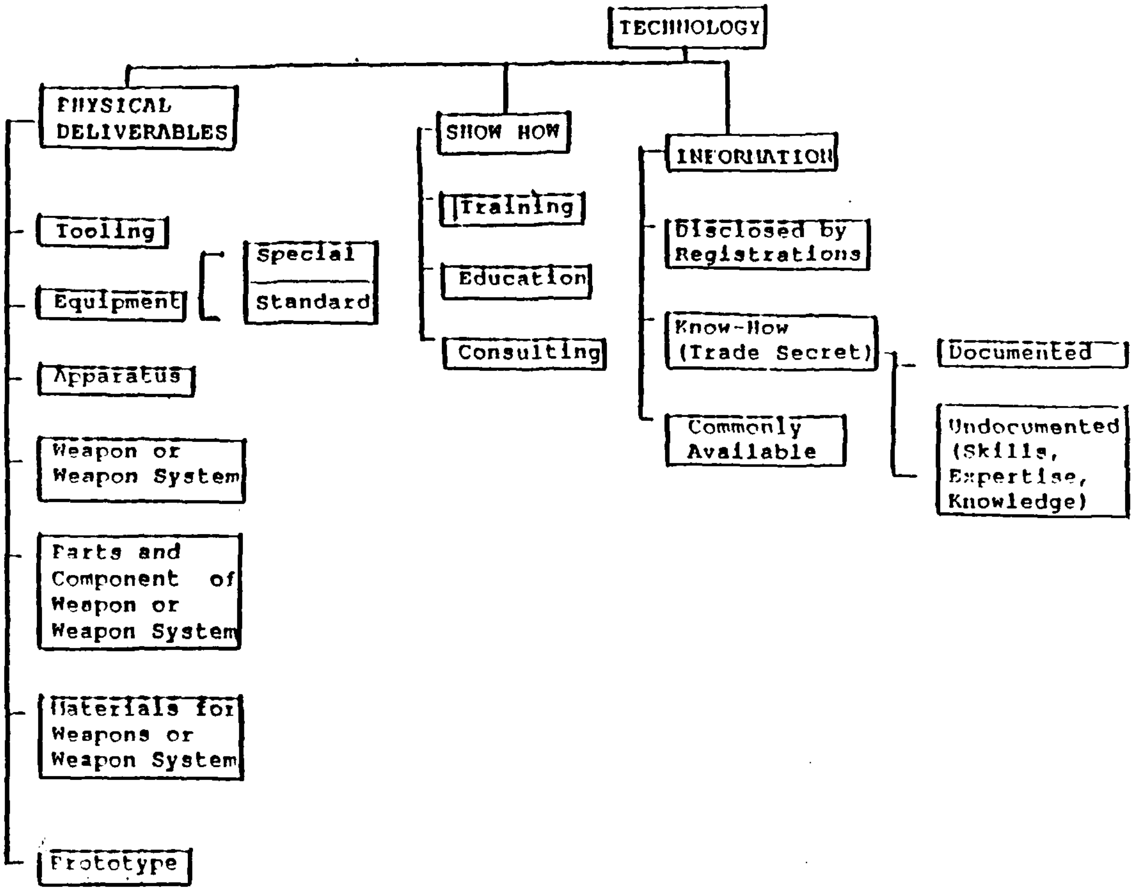
hydroboats, and tank landing ships constitute major sea weapons. Major missile/radar systems include anti-tank missiles, surface-to-air missiles, air-to-air missiles, ship-to-ship missiles, and radar systems.



Source: Adapted from Office of Industrial Innovation, *Supplying or Acquiring Technology: A Canadian Business Guide to Structuring and Negotiating Technology Transfer Agreements*, Department of Regional Industrial Expansion, 1986, p. 7.

Figure 1. Forms of Military Technology

Engineering drawings, parts requirements, aircraft specifications, electrical wiring diagrams, stress reports, performance characteristics and supporting aerodynamic data, process specifications, material specifications, list of ground-handling and maintenance equipment, Lockheed's Drafting Practice Manual, flight-test procedure cards, Pilot's Operation Handbook, flight-test reports, weight reports, production operation sheets, detail assembly-panel charts, tool design, lists of suppliers of all parts, equipment, and assemblies, Functional Test Manual, Planning Manual, Standards Tool Manual, Manufacturing Standard Manual, Manufacturing Process Manual, Tool Design Manual, major-assembly sequence chart, bill of material, and an illustrated parts catalog.

B. DEVELOPMENTS IN MILITARY TECHNOLOGY

Between 1789 and 1807, during the reign of Sultan Selim III of the Ottoman Empire, the range of a musket was about 200 meters(m). It took 30 seconds to load. At the end of the nineteenth century, the musket was replaced by the repeating rifle and the machine-gun which not only increased the rate of fire, but also increased the range to 1000 m or more. At the same time, quickfiring artillery superceded old fashioned cannons (Lumsden, 1980, pp. 24-25).

Although major innovations in military technology, such as aviation, tanks and military electronics of many kinds took place during the Second World War (Williams, 1982, pp. 369-382), there have also been extensive developments in conventional military technology since the end of World War II. Some examples follow (Leintenberg, 1973, pp. 338-339):

1. Extensive computer-controlled air-defense networks with large, early-warning, over-the-horizon radars for ballistic missile warning and forward emplaced radar networks for anti-aircraft defense. Self-guided target-seeking air-to-surface missiles.

2. Electronics and air-borne computers play a nearly complete role in advanced combat aircraft: navigation, reconnaissance, bad-weather operations, engaging opposing aircraft, fire control, weapons guidance. Airborne anti-submarine warfare has undergone enormous development, long-range, long duration patrols, expandable sonobuoy systems, other buoy telemetry, airborne dipped sonars, infra-red and magnetic anomaly surveillance.

3. Advanced weapon guidance, using lasers for targeting of many kinds of ordnance in field weapons and ground-support aircraft. Night-time target acquisition and fire-control devices. Radars for artillery and mortar location.

4. The impact of artificial intelligence on military technology and tactics may be tremendous. It is expected to see greater autonomy, sophistication and dispersion of weapons systems and personnel (Martin, 1983, p. 3). Three specific military areas targeted for initial application of artificial intelligence are an autonomous land vehicle, an intelligent Pilot's Associate, and naval battle management (Encyclopedia of Artificial Intelligence, 1987, p. 604).

5. There is a potential of applying robotics to the battlefield. It is suggested that robotics must first replace people in hazardous jobs, such as combat, since those people can be killed. Second, robotics should replace people in military jobs that may not be hazardous, such as in logistics, to decrease the overall investment in the armed forces. Third, robotics should be used in those applications, particularly in combat, that can overcome the disadvantage in numbers of personnel. (Brownstein and others, 1983, p. 171)

Improvements in the performance of fighter-bombers may give a general idea about overall documents in military

technology after the Second World War. Aircraft speed, range, load capabilities, and other operating characteristics have continued to improve since World War II, as shown in Table 1.

Table 2 shows the relative capabilities of tactical attack aircraft forces during World War II and currently in terms of an arbitrary but meaningful measure--the potential to destroy tanks or bridges. It is clear that although modern aircraft are much larger and more expensive, a much smaller force can now do much more than was possible in World War II (Deitchman, 1983, p. 45).

Currently, the average life span of advanced military technology, such as tank and combat aircraft, is estimated at less than 10 years. In the case of electronics and computers, the average life span is 5 years. Thus, at least every decade a new generation of weapons is produced. (Steinberg, 1986, p. 296)

On the other hand, to maintain technological superiority, the new military systems can be costly, both in development and in production. An illustration of military technological development and their ever increasing unit costs is given in Figure 2 on costs for successive generation of United States tactical aircraft.

TABLE 1. COMPARATIVE PERFORMANCE INDICATORS OF FIGHTER-BOMBERS, 1942-1985

		Approximate Performance[a]		
Year	Aircraft	Combat Speed Knots	Radius Nautical Miles	Weapon Load (typical)
1942	A-36 Invader (version of P-51A)	280	150-200	4 .50-cal guns 2 500-lb bombs
1944	P-51H	350	400	6 .50-cal guns 2 1,000-lb bombs
1955	A4-C[b]	500	600-800	2 20-mm cannon 3 store stations capable of 5,000-lb bomb load
1960	F4 B[b]	500[c]	850	16,000 lb of payload (e.g., 11 1,000 lb bombs or bombs plus gun pods and rockets)
1964	F-111A[d] (Mach 1.2 at sea level)	700[c]	Over 1,300	45,000 lb, of fuel + weapons 8 store stations + internal bomb bay
1975	A-10A	390	250 + 2.2 hrs."loiter" over battlefield	30-mm, 6 barrel Gatling gun + 16,000 lb payload on 11 store stations
1980	A-16A	500[c]	500	1 20-mm cannon 7 store stations capable of total load up to 20,000 lb + wingtip air-to-air missile stations
1985 (est)	AV-8B Vertical or short takeoff & landing	500	150 + 1 hr.	9,200 lb. (bombs, gun loiterpods, or missiles) on 9 store stations

[a] These are simply indicators of performance that do not especially go together. Speed is less than maximum; radius with heavy weapon load would be less than shown.
[b] These aircraft (as later versions) still active in the forces.
[c] Arbitrary ground attack speed: aircraft capable of Mach 2 performance.
[d] Data as of 1976

Source: Seymour J. Deitchman, *Military Power and the Advance of Technology: General Purpose Military Forces for the 1980s and Beyond*, Westview Press, 1983, p. 42.

TABLE 2. COMPARISON OF WORLD WAR II AND CURRENT TACTICAL AIR ATTACK CAPABILITY

CATEGORY	WORLD WAR II	CURRENT[a]
Number of aircraft	About 2,500 (P-47,P-51, Hurricane B-25, B-26)	100 (F-4, A-7, A-10)
Sorties per day per aircraft	0.61	1-3
Average bomb load	2,500-lb bombs or equiv	8-18 500-lb bombs or 3-6 PGMs[b]
Tank equivalents Damaged or destroyed by force, per day	60-70[c]	300-800[d] (using PGMs)
Sorties to destroy bridge over minor river	20-30	1 (using PGMs)

[a] Estimated
[b] Depends on number of pylons, weight each can hold, and type of PGM (precision guided munition)
[c] Based on estimated effectiveness of weapons, typical accuracy, and average bomb load per sortie
[d] Depending on type of aircraft and combat conditions

Source: Seymour & Deitchman, *Military Power and the Advance of Technology: General Purpose Military Forces for the 1980s and Beyond*, Westview Press, 1983, p. 45.

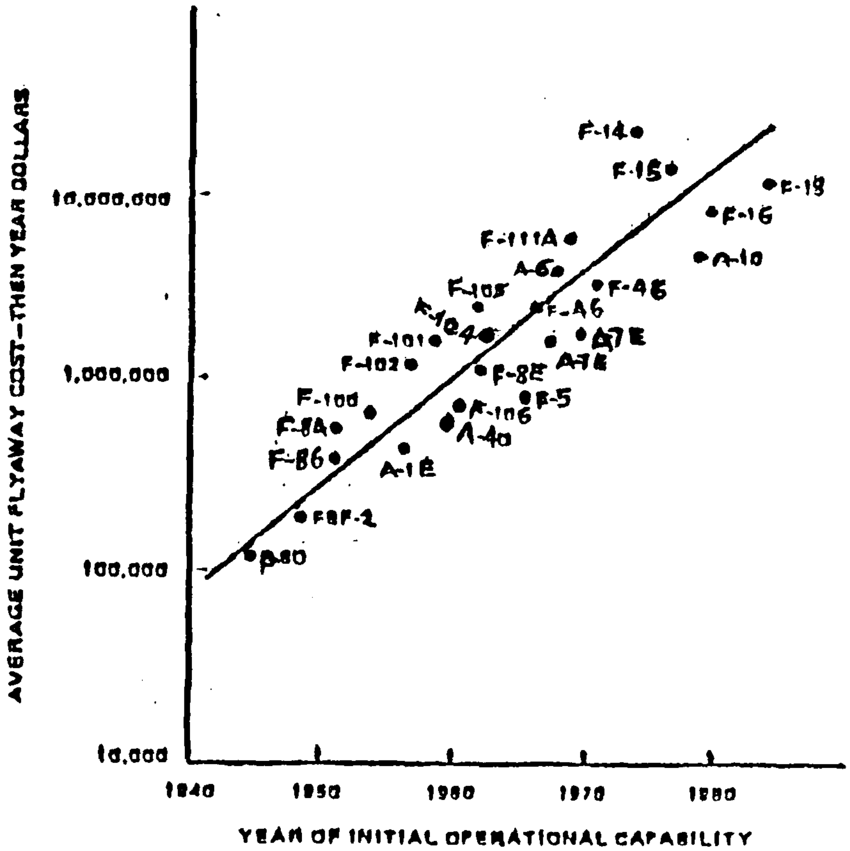
There are two important facts that can be observed from Figure 2. First is the large number of new models of fighter aircraft: 25 of them in 40 years. The other is the 100--fold increase (in current dollars) in the cost of a single, fully equipped, tactical aircraft. It is obvious that the latest models are far more effective fighting machines. However, the big increase in cost per unit has so reduced the total number of aircraft that can be purchased that the cost effectiveness of the superior technology becomes uncertain. (Long, 1983, p. 218)

C. PURPOSE OF THE STUDY

The major objective of this study is to place the issue of the transfer of military technology to Turkey within the general context of international transfer of military technology to developing countries.

Recently, Turkey has been developing a number of technological and industrial areas to improve indigenous arms production[2].

[2]Indigenous arms production in which the essential stage of a certain weapon or a weapon system is carried out in the country.



Source: F. A. Long, "Advancing Military Technology: Recipe for an Arms Race," *Current History*, May 1983, p. 218.

Figure 2. Cost Trend in Tactical Aircraft

But the growth of the military technological base is not sufficient. There is a "technological gap" that has to be fulfilled. Therefore, this study is aimed to propose a strategy for efficient transfer of military technology to Turkey.

D. SCOPE

The concern of this study is the process transfer of conventional military technology to developing countries. It excludes the transfer of nuclear, biological and chemical military technologies.

Mostly, sales of technical data, blueprints, production equipment and raw materials are not incorporated in the statistical data by Congressional Research Service, U.S. Arms Control and Disarmament Agency, Stockholm International Peace Research Institute and U.S. Library of Congress. Therefore, in this study, all valuation statistics refer to the major weapons only.

Throughout this study, the term "developing country" is used to refer to a country having annual per capita income of $3,000 or less.

E. ORGANIZATION OF THE STUDY

In this study, first, we discuss the potential of arms production in Turkey. Then, a theoretical model, reasons, vintages, and strategies of military technology transfer are examined. Finally, after discussions of channels of military technology transfer, advantages, disadvantages, and the effects of the transfer are presented.

II. THE POTENTIAL OF ARMS PRODUCTION IN TURKEY

A new development in the military activities of developing countries is the growing importance attached to indigenous arms production.

From the mid-1970s on, several factors have added impetus in Turkey's drive for domestic arms production. These include reducing the dependency on foreign suppliers, saving foreign exchange, creating employment, and updating her military technology. However, producing weapon systems relies heavily on the nations' industrial capability, technological base and human capital. In this chapter, we will discuss the arms production base of Turkey emphasizing the industrial capacity.

A. ORIGINS

The Turkish defense industry began to emerge during the Ottoman Empire. The first cannon and howitzer in history were made during the reign of Sultan Mehmed II, the Conqueror. In this period, Tophane-i Humayun was established to produce cannons. Engineers Muslihiddin and Sarica Sekban designed 130 cannons used during the conquest of Istanbul.

Weapons production was improved and developed during the sovereignty of Suleyman the Magnificent. Tophane-i Humayun

began to produce relatively modern weapons when Halil Pasha was assigned as a consultant to the project.

Caka Bey established the first Turkish naval shipyard and naval base in the eleventh century in Izmir.

In the seventeenth century, Hazerfen Ahmed Celebi flew from Galata Tower in Istanbul over a distance of about 6,000 meters by using a wing-like device.

Although the Ottoman Empire was the innovator in methods of warfare and weapons, Turkish arms production had fallen behind its counterparts by the beginning of the twentieth century.

In the first years of the Republic of Turkey, military production facilities of Istanbul, Erzurum, Eskisehir and Ankara were reorganized in Ankara in 1921, under the General Directorate of Military Factories (Askeri Fabrikalar Umum Mudurlugu). In 1950, this establishment, in turn, reorganized into a state economic enterprise as the General Directorate of Mechanical and Chemical Industries (Makina ve Kimya Endustrisi Kurumu Genel Mudurlugu--MKEK).

With the cooperation of Americans, the Kayseri aircraft factory, in 1932, started the production of Curtis Hawk fighters and 10 Fleshing trainers. Production of 15 German Gotha 145 training and transport aircraft, 22 Polish Plz-23

and 25 British Magister trainers followed and the production of these aircraft continued until 1939 in Kayseri. (Akgul, 1986, p. 109)

In 1936, Nuri Demirag opened his factory in Besiktas and an assembly shop in Yesikoy near Istanbul. In these facilities, 15 ND-37 trainers developed by Selahattin Alan were manufactured and used for pilot training. The ND-37 was supposed to be followed by the twin-engine, 8-seated ND-38 which was ready for manufacturing, but work ended when the German engineers returned to Germany. For some time, the factory continued to produce parts for Westland Lysunder reconnaissance aircraft but stopped manufacturing in 1943. (Akgul, 1987, p. 194)

During the Second World War, Polish engineers emigrating from German-occupied Poland came to Turkey. With their cooperation, an aircraft factory was founded in Ankara, Etimesgut, in 1941. At first, 60 Fourga Magisters were produced. Later, under the name of the Turkish Air League (THK), some other aircraft and gliders were manufactured. The aircraft factory was handed over to MKEK by law. Following this takeover, the Turkish Air Force ordered 100 aircraft in 1953, but only 60 MKEK-4 Ugur aircraft were manufactured. The projects of the MKEK-3 Mehmetcik jet

trainer and Gozcu artillery reconnaissance aircraft were prepared but manufacturing stopped in 1959. Repair and overhaul work continued until 1965. Five of the twin-engine THK aircraft were exported to Denmark and three Ugurs were given to Jordan as a present. (Akgul, 1987, p. 196)

On the basis of a license from de Havilland Engines, the THK aircraft engine factory was founded in 1945 on the basis of a license from de-Havilland Engines to produce Gipsy major engines. Manufacturing started in 1948, but later financing became difficult, and the company was turned into a tractor factory in 1955.

B. THE STRUCTURE OF THE TURKISH DEFENSE INDUSTRY

In order to improve arms production in Turkey, the Defense Development and Support Administration (DIDA) was put into implementation in 1985 as an umbrella organization in the defense industry.

Defense Development and Support Administration endeavors to provide the financial resources, with the purpose of ensuring the selection of the most suitable technologies, securing the necessary coordination between the public, military and private sectors, and supporting and encouraging new defense oriented enterprises.

Organization in the Turkish arms production can be classified into three categories (Akgul, 1988, pp. 106-110):

1. Government-Owned Defense Industry Plants
2. Armed Forces Plants
3. Private Enterprises

Government-owned defense industry plants are tasked to meet the needs of the Turkish Armed Forces in the fields of weapons, ammunition, explosives, and electronic equipment. TUSAS Aerospace Industry is in the process of assembling F-16 C/D combat aircraft.

The armed forces plants are used for the overhaul of military vehicles. Capabilities include production and maintenance of various items of equipment, components and communications equipment. There are also naval yards which produce and overhaul warships.

Some companies in the private sector participate in production activities for various types of military trucks, wheeled vehicles, various materials and equipment for the Turkish Armed Forces.

C. REQUIREMENTS OF ARMS PRODUCTION

There are several socioeconomic and industrial factors that separate developing countries into arms producers and arms nonproducers.

1. Socioeconomic Indicators

Neuman (1984, pp. 167-170) discusses some factors that separate weapon producer developing countries from others. She ranks developing countries in relation to a weighted index of military production capability derived from length of production, production capacity, and technical capabilities and also according to seven socioeconomic indicators:

1. Population
2. Land size
3. Size of military
4. Gross national product (GNP)
5. GNP per capita
6. Number of professional and technical workers
7. Number of industrial workers

In her article, Neuman (1984, p. 185-186) concludes that in developing countries there exists "a hierarchically shaped arms production system based largely on factors of scale". Moreover, she states that "the existence of a large military to provide an adequate market, combined with a generous national income and sizable population to support the necessary infrastructure, significantly affect a state's long-term ability to produce weapon systems as well as the

quantity and sophistication of its product" (Neuman, 1984, p. 185-186).

On the other hand, Looney and Frederiksen (1986, p. 746) incorporate into their analysis other factors that Neuman's analysis excludes such as contact with the world economy, public debt, and growth in foreign trade. In addition, they mention that successes of a producer will depend on a highly developed collateral industry, a supportive government and general industrial development.

Their result indicates that "although size and military expenditures are important in determining whether a country will produce a major weapon, the nature of arms production necessitates a certain economic environment for the process to be profitable". (Looney and Frederiksen, 1986, p. 752)

Turkey has a unique geographic location with an area of nearly 800,000 square kilometers. The population of Turkey is about 55 million and she has over 800,000 troops. In 1985, the GNP of Turkey was $50,850 million and GNP per capita was slightly over $1,000. In 1988, the total debt of Turkey was $39,200 million[3].

[3]Republic of Turkey, State Planning Organization, and Central Bank.

Overall, Turkey allocates about 5% of its GNP and 25% of its national budget to defense (Turkgenci, 1987/1988, p. 30). This allocation highly stimulates the need for the indigenous arms production.

2. Industrial Base

Weapon systems with high technology are produced from many different kinds of industrial metals, materials, components and parts. A weak industrial infrastructure together with inadequate technological level and technical personnel impose limitations on domestic arms production. Therefore, the industrial base, human capital and technological base are pre-conditions for initial arms production. (Brzoska and others, 1980, p. 38)

Arms production has technical linkages with certain industries rather than the total industrial capability (Deger, 1986, p. 164). Industrial employment in defense production in the United Kingdom which point to the following industries as being the most important (Ayres, 1983, pp. 816-817):

1. Explosives and firearms
2. Iron and steel
3. Steel tubes
4. Light metals
5. Metal working
6. Engineers' small tools and gauges

7. Industrial engines

8. Other machinery

9. Ordinance and small arms

10. Other mechanical engineering

11. Scientific surgical and photographic instruments

12. Electrical machinery

13. Insulated wires and cables

14. Telegraph and telephone apparatus

15. Radio and other electronic apparatus

16. Other electrical goods

17. Ship-building and ship-repairing

18. Metal industries

19. Rubber

Kennedy (1974, pp. 296-297), and Wulf (1983, p. 324) stress the importance of seven major industrial categories of manufacturing within the International Standard Industrial Classification (ISIC) that encompass the above list for domestic arms production:

1. Iron and steel

2. Non-ferrous metals

3. Metal products

4. Machinery

5. Electrical machinery

6. Ship-building and repairing

7. Motor vehicles

This framework is referred to as Potential Arms Production Base (PAPB) by Wulf (1983, p. 324) and the Potential Defense Capacity (PDC) by Kennedy (1974, p. 296). Henceforth, we will use the term PAPB. If it is compared to total manufacturing capacity, then an indication can be obtained of the viability of a country's arms production programs (Matthews, 1988, p. 15). Obviously, the higher the ratio, the greater the potential to produce weapons.

Table 3 shows the share of PAPB sectors in whole manufacturing capacity for Turkey. If one takes employment, output or value added as the proportion of total manufacturing capacity in the PAPB group is considerable. This is the case whether the index is measured in terms of employment (27.7%), output (25.4%) or value added (20.6%).

As Table 4 indicates, Turkey has a better potential for arms production than countries like Israel, Chile, Indonesia, Egypt, Pakistan, Singapore and Greece, just to mention a few which produce at least one major weapon system.

TABLE 3. THE SHARE OF PAPB IN TOTAL MANUFACTURING IN TERMS OF EMPLOYMENT, OUTPUT, AND VALUE ADDED, 1984

ISIC	Industrial group	Average number of employees (thousands)	Output in producers' prices (billion TL)	Value added in producers' prices (billion TL)
371	Iron and steel	46.0	705	153.9
372	Non-ferrous metals	21.6	247	73.5
381	Metal products	37.5	276	106.6
382	Machinery	37.6	550	162.1
383	Electrical machinery	35.0	454	178.0
3841	Shipbuilding and repairing	6.0	29	17.8
3843	Motor vehicles	33.8	467	161.4
	Total PAPB	227.5	2,728	691.9
	Total Manufacturing	820.9	10,750	3,357.0
	Total PAPB as a percentage of total manufacturing	27.7%	25.4%	20.6%

Source: Department of International Economic and Social Affairs, Statistical Office of the United Nations, *Industrial Statistics Yearbook 1985*, United Nations, Vol. 1, 1987, pp. 542, 545-546.

TABLE 4. RANKS OF ACTUAL AND POTENTIAL CAPACITY FOR DEFENSE INDUSTRIES

	COUNTRY	ACTUAL ARMS PRODUCTION	POTENTIAL FOR ARMS PRODUCTION
1	Israel	1	6
2	India	2	3
3	Brazil	3	2
3	Yugoslavia	4	1
4	South Korea	5	4
5	Turkey	6	5
7	Indonesia	7	15
8	Egypt	8	11
9	Pakistan	9	16
10	Singapore	10	12
11	Iran	11	9
12	Colombia	12	14
13	Portugal	13	8
14	Greece	14	10
15	Venezuela	15	13
16	Nigeria	16	17
17	Chile	17	7

Source: Saadet Deger, *Military Expenditure in the Third World Countries: The Economic Effects,* Routledge & Keagen, Paul, 1986, p. 170

In a period of about ten years, from almost zero level, Brazil has moved to become the third largest arms producer and seller among the Third World countries[4]. (Deger, 1986, p. 171)

The share of the potential defense capacity of Turkey in total manufacturing in terms of employment, output and value added is considerable and higher than it was for Brazil when it was building up its defense industry in the 1960s. (Ayres, 1983, p. 817)

There are both public and private sector enterprises in the iron and steel industry. Public sector plants include the steel mill of MKEK and iron-steel plants of Karabuk, Eregli and Iskenderun. The Karabuk plant has been operating since 1936 with a capacity of 0.6 million tons and the Iskenderun integrated factory has been functioning since 1976 with a capacity of 2.2 million tons. The third entity is Eregli which has a 1.8 million ton crude steel processing capacity. Total capacity of integrated plants is 4.6 million tons per year. (Cakmakci, 1987, p. 16)

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[4]It is estimated that annually, Brazil sells one thousand armored and other vehicles in transactions against oil from Middle East and Africa. Brazil's main sales lines are the amphibian Urutu, the Osorio tank which is similar to the U.S. M-1 model, the Cascavel armored car and the Jaracca light reconnaissance vehicle.

Furthermore, there are 15 private factories with a total capacity of 2.7 million tons per year ranging from 50,000 to 1,000,000 tons each. (Cakmakci, 1987, p. 16)

The total steel production reached 4.9 million tons in 1985. The export of iron-steel products was $519.8 million in 1984 and $864 million in 1985. On the other hand, Turkey imports semi-finished products (i.e., blum, slab), hot rolled sheets, special quality steel, and seamless pipes in considerable quantities. (Cakmakci, 1987, p. 17)

Since 1960, integrated aluminum, copper and zinc facilities have been set up for the production of non-ferrous metals. The aluminum production capacity of Turkey is about 60,000 tons per year.

Public and private plants produce light and heavy diesel engines for vehicles in land transportation, engines for locomotives and for all kinds of tactical and armored vehicles.

Moreover, small and medium size hydraulic turbines, generators and electrical motors, all kinds of gears and transmissions, various types of gear pumps and accessories for hydraulic equipment and control systems, all forged parts and undercarriages of excavators, and all the special steel

material requirements of automotive industry are produced in Turkey.

In the shipbuilding industry, the ship construction capacity has reached 70,000 DWT (Cakmakci, 1987, p. 7).

Military Electronics Industry, Inc (ASELSAN) produces VHF/FM vehicles, personnel and stationary type devices for military purposes.

Considerable amounts of electromechanical components, transformers, bobbins circuit elements, resistors, capacitors, communication instruments, and industrial electrical devices are produced in Turkey.

An automotive industry began having importance in total production. Its efforts drew towards manufacturing instead of assembly in the 1960s. Currently, more than 300 large establishments manufacture in this sector. The production was about 140,000 units in 1986. In the same year, 19% of the production was exported. (Cakmakci, 1987, pp. 14-15)

Turkey has always welcomed foreign investment[5], and especially that which is engaged in high technology production. A major reason for this is that much of its potential arms production capacity represents the consumer-good machinery and assembly industries.

A large proportion of the manufacturing sector's process machinery still has to be imported. In 1986, 31.2% of Turkey's imports represented investment goods. The share of industry in total export has increased from 36% in 1980 to about 72% in 1986 (Cakmakci, 1987, pp. 1-2).

The design, manufacture and assembly of most weapons requires skilled manpower. In 1984, Turkey had 117,500 engineers in various branches of engineering, more than 100,000 technicians and about 200,000 skilled workers (Cakmakci, 1987, pp. 28-30). Scientists and engineers that worked in research and development at the beginning of the 1980s were about 9,000 persons (Wulf, 1983, p. 327).

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[5]The basic law regulating foreign investment in Turkey conveys to foreign investors the same rights and privileges as to the Turkish investors and guarantees the freedom to transfer profits, fees and loyalties, and repatriate capital in the event of liquidation or sale. Virtually, all sectors of business activity in Turkey are open to foreign investment.

3. Productive Performance of PAPB Sectors

Between the end of the 1970s and the beginning of the 1980s, Turkey's PAPB industries, except for the iron and steel industry, enjoyed a considerable growth. Tables 5 through 8 provide the data on the productive performance of these industries over the period 1977-1984.

Table 5 shows that the real growth rate of the PAPB sectors' value added amounted to an annual average of 0.7%. Except iron and steel, and shipbuilding and repair industries, it can be seen that all sectors produced growth. Similarly, saving these two industries, Table 6 indicates that labor efficiency in all sectors rose over the 7-year period.

As Table 7 demonstrates, saving the performance of iron and steel, and metal products there was a real growth trend for capital productivity. The remarkable 11.3% growth in gross fixed capital formation was due to the buildup of capacity in aircraft and shipbuilding industries.

On the other hand, Table 8 shows that the real growth rate of the PAPB sectors' profitability was 1.6% in the period under consideration. It was largely because of the profits that some Western multinational companies showed no reluctance to participate in Turkey's industrial expansion. For instance, in 1986, the foreign investment approvals amounted

to 1,670 million dollars and 536 foreign companies (220 of them in manufacturing industry) have been operating according to the foreign capital law. That same year, the foreign capital share in total capital was 34.7%. (Cakmakci, 1987, pp. 24, 26)

4. Weaknesses

A serious domestic supply deficiency concerns high-precision machine tools. Although it is crucial to arms production, the domestic machinery industry having the capacity to produce a broad range of advanced machinery has not developed them in Turkey. New products are mainly introduced into the market through licensed production of foreign designs.

In 1986, over 90% of all imports were for investment goods and raw material (Cakmakci, 1987, p. 2), precisely the inputs required for arms production. Moreover, one of the most important reasons of the negative real growth rate in the iron and steel industry is importation.

As the discussion reveals, Turkey has a relatively adequate manufacturing base and human capital for initial arms production. *However, there is a technological gap. In order* to fulfill this gap, Turkey has to seek the transfer of military technology.

TABLE 5. PRODUCTIVE PERFORMANCE OF PAPB INDUSTRIES, 1977-1984* (VALUE ADDED)

Industrial Group	Value Added in Producers' Prices (billion TL)				Annual Average growth %
	1977	1979	1982	1984	
Iron and Steel	20.6	36.8	96.3	153.9	-11.5
Non-ferrous Metals	3.7	11.4	31.0	73.5	1.5
Metal Products	5.0	16.4	59.5	106.6	2.7
Machinery	6.5	19.0	89.9	162.1	5.1
Electrical Machinery	6.3	16.3	70.4	178.0	7.0
Shipbuilding and Repairing	1.1	2.8	18.6	17.8	1.2
Motor Vehicles	8.6	16.1	77.3	161.4	0.9

*Data for value added expressed in current prices: the annual average growth rates are in constant prices (1963=100)

Source: Department of International Economic and Social Affairs, Statistics Office of the United Nations, *Industrial Statistics Yearbook 1981*, United Nations, Vol. 1, 1983, p. 525; and *Industrial Statistics Yearbook 1985*, United Nations, Vol. 1, 1987, p. 546.

TABLE 6. PRODUCTIVE PERFORMANCE OF PAPB INDUSTRIES, 1977-1984 (AVERAGE NUMBER OF EMPLOYEES)

Industrial Group	Average Number of Employees (thousands)				Annual Average growth %
	1977	1979	1982	1984	
Iron and Steel	55.1	60.2	55.1	46.0	-2.5
Non-ferrous Metals	19.7	20.4	21.6	21.6	1.3
Metal Products	31.0	37.2	40.9	37.5	2.8
Machinery	40.2	46.4	52.4	47.6	2.4
Electrical Machinery	28.1	31.1	33.1	35.0	3.2
Shipbuilding and Repairing	7.1	8.8	8.9	6.0	-2.4
Motor Vehicles	32.4	31.0	30.1	33.8	0.6

Source: Department of International Economic and Social Affairs, Statistics Office of the United Nations, *Industrial Statistics Yearbook 1981*, United Nations, Vol. 1, 1983, p. 523; and *Industrial Statistics Yearbook 1985*, United Nations, Vol. 1, 1987, p. 542.

TABLE 7. PRODUCTIVE PERFORMANCE OF PAPB INDUSTRIES, 1977-1984* (GROSS FIXED CAPITAL FORMATION)

Industrial Group	Gross Fixed Capital Formation (million TL)				Annual Average Growth %
	1977	1979	1982	1984	
Iron and Steel	1,801	10,024	20,309	20,950	-5.8
Non-ferrous Metals	543	695	6,152	25,253	14.9
Metal Products	636	1,311	6,417	10,707	-0.7
Machinery	693	1,831	9,982	22,624	9.2
Electrical Machinery	543	762	6,809	30,083	17.8
Shipbuilding and Repairing	29	121	2,769	3,653	32.4
Motor Vehicles	1,195	2,920	14,475	43,957	11.1

*Data for gross fixed capital formation is expressed in current prices: the annual average growth rates are in constant prices (1963=100)

Source: Department of International Economic and Social Affairs, Statistics Office of the United Nations, *Industrial Statistics Yearbook 1981*, United Nations, Vol. 1, 1983, p. 525; and *Industrial Statistics Yearbook 1985*, United Nations, Vol. 1, 1987, p. 546.

TABLE 8. PRODUCTIVE PERFORMANCE OF PAPB INDUSTRIES, 1977-1984* (VALUE OF STOCKS)

Industrial Group	Value of Stocks at the End of period (billion TL)				Annual Average growth %
	1977	1979	1982	1984	
Iron and Steel	10.14	18.76	71.7	129.1	-4.5
Non-ferrous Metals	2.77	7.44	24.6	64.0	3.9
Metal Products	3.29	9.36	32.4	51.8	-1.6
Machinery	5.34	16.69	72.3	111.2	2.4
Electrical Machinery	3.63	10.19	37.5	83.9	3.9
Shipbuilding and Repairing	0.49	0.88	7.3	13.1	6.1
Motor Vehicles	5.12	12.61	41.7	85.8	-0.7

*Data for value of stocks at the end of period is expressed in current prices: the annual average growth rates are in constant prices (1963=100)

Source: Department of International Economic and Social Affairs, Statistics Office of the United Nations, *Industrial Statistics Yearbook 1981*, United Nations, Vol. 1, 1983, p. 526; and *Industrial Statistics Yearbook 1985*, United Nations, Vol. 1, 1987, p. 547.

III. MILITARY TECHNOLOGY TRANSFER: AN OVERVIEW

This chapter analyzes mainly a theoretical model, reasons, sources, vintage and strategies of military technology transfer.

A. THEORETICAL MODEL OF MILITARY TECHNOLOGY TRANSFER

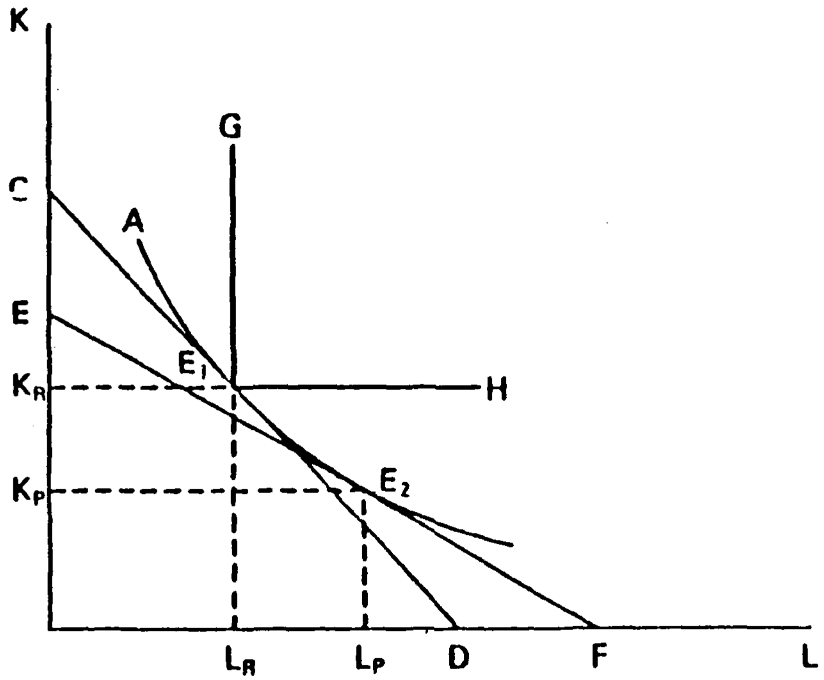
Deger (1986, pp. 178-179) has introduced a theoretical model to explain the military technology transfer from developed to developing countries.

Let us consider Figure 3. There exists a military technology where the output of arms (D) is produced by two factors: capital (K) and labor (L). Suppose prior to technical change there is a high possibility of substitution between K and L, so that D can be produced by a widely different range of capital-labor ratios. The usual shaped isoquant AB in Figure 3 represents current technology.

Suppose this technology is freely available. A developed country with higher capital endowments will choose to produce output at E_1 with the slope of CD giving the wage-rental ration. The factors in use will be K_R and L_P. An underdeveloped country with abundant labor and lower wage-

rental ratio will produce at E_2 using more labor (L_P) and less capital (K_P).

Given the sophistication and costs of military research, most technical progress in defense production takes place in developed countries. Therefore, when technology is induced in DCs, they will work to move out the production frontier around the point at which they are currently located, developing a very specialized technology appropriate to their own wage-rental ration. In the model, in the limit, there will be an L-shaped isoquant where there is no possibility of substitution between the two factors. Since the innovation comes from the economy where wage rental is high, it is expected that the vertex of the isoquant which is the most efficient point will be at E_2. Thus, the technology will be useful for the country having low labor but high capital stocks. The total effect of DC-induced innovation and the shrinking of the substitution possibility will give a new isoquant of the type GE_1H. (Deger, 1986, p. 178) It is obvious that, this new technology is inappropriate for developing countries, unlike the old one.



Source: Saadet Deger, *Military Expenditure in Third World Countries: The Economic Effects*, Routledge & Kegan Paul, 1986, p. 178.

Figure 3. Theoretical Model of Military Technology Transfer

In order to use techniques most efficiently, a developing country might have to shed labor and create unemployment, or alternatively, at L_P, increase capital stock substantially to reach the relevant optimum point of the isoquants. Clearly, inappropriate technology is the bane of developing countries. This is especially true in military-oriented fields, where

technical progress is faster, usually induced in developing countries with more investment and, research and development infrastructure, often needs to be imported without control or adaptation, and involves massive resource costs, especially the inputs which are in short supply. (Deger, 1986, p. 179)

From a purely efficient point of view, it may be optimal for developing countries to choose the most efficient technology. However, increasing proportions being spent on new vintages will, by increasing obsolescence, make the resource cost prohibitive. At the same time, the macroeconomic cost of inappropriate technology will have to be considered also. Labor-surplus developing countries might be saddled by highly capital-intensive methods of production leading to a choice of techniques incompatible with endowments and factor-price ratios. Thus, although military technology transfer may have beneficial effects, the costs will be high.

B. REASONS FOR MILITARY TECHNOLOGY TRANSFER

The three major reasons for transferring military technology to developing countries can be stated as follows:

1. The Desire for Domestic Arms Production

2. Economic Factors

3. Technological Characteristics of Arms Production

1. The Desire for Domestic Arms Production

Developing countries have jointly comprised the world's leading market for conventional weapons, accounting for as much as three-quarters of the international trade in military systems. Between 1978-1985, the developing countries ordered $258 billion (in current dollars) worth of weapons systems and ammunition from arms suppliers and actually received $220 billion worth of such equipment. In these transactions, 13,960 tanks and self-propelled cannons, 27,605 armored personnel carriers, 4,005 supersonic combat aircraft, and 34,948 surface-to-air missiles were included. (Grimmett, 1986, pp. 30, 36)

Although these transfers resulted in a significant shift in military technology from developed to developing countries in the form of hardware, there is an apparent decline in arms purchases by the developing countries. From a high point of $43.6 billion in 1982, developing countries orders for new weapons dropped to $28.2 billion in 1983, $32.2 billion in 1984, and $29.9 billion in 1985 (in current dollars) (Grimmett, 1986, p. 30).

Accompanying this contraction in the total market share of the six major suppliers, there have been some important shifts in the relative market dominance of the individual suppliers. Most noticeable in this regard is a shift in the respective shares of the two superpowers on one hand and the four European suppliers on the other. Between 1973 and 1980, the U.S.A. and the Soviet Union jointly received 66 percent of all developing countries orders while Europeans received 25 percent. However, in 1984, the superpowers' share had dropped to 55 percent while the Europeans' share rose to 32 percent. (Klare, 1987, p. 1262)

On the other hand, the annual value of the production of weapon systems in developing countries has grown dramatically between 1950 and 1984. In 1950, the production of weapons was valued at nearly 2.3 million (in constant 1975 prices) or roughly equivalent to the cost in the mi -1980s of one main battle tank. However, in 1984, this value was about 500 times higher (Brzoska and Ohlson, 1986a, p. 7).

Although these developing countries continue to rely on the major developing countries for high-performance jet aircraft and other sophisticated military systems which exceed their domestic manufacturing capabilities, they have become relatively self-sufficient in the production of small arms

artillery, trainer and counter-insurgency aircraft, and other basic items. (Klare, 1987, p. 1267)

As Table 9 indicates, ten developing countries now produce fighters, eight produce helicopters, six produce battle tanks, eight produce missiles, and six produce major fighting ships.

As seen in Table 10, at the beginning of this decade, perhaps the most important development is the gradual growth in arms sales by developing countries which lack the extensive production capabilities of the six major suppliers. However, they have succeeded in striking out a significant market as suppliers of inexpensive or specialized equipment.

As the data suggests, there is a switch from direct arms sales to military technology transfer such as blueprints and technical information to produce arms in the name of self-sufficiency.

TABLE 9. PRODUCTION YEARS FOR SELECTED WEAPON SYSTEM IN DEVELOPING COUNTRIES

Country	Year[a] 1965	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
Fighters[b]																				
India	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
South Africa				x	x	x	x	x	x	x	x	x	x	x	x	x				
Brazil							x	x	x	x	x	x	x	x	x	x	x	x	x	x
Israel								x	x	x	x	x	x	x	x	x	x	x	x	x
Taiwan										x	x	x	x	x	x	x	x	x	x	x
Korea-North											(x)	(x)								
Argentina											x	x	x	x	x	x	x	x	x	x
Korea-South																x	x	x	x	x
Egypt																		x	x	x
Chile																				x
Helicopters																				
India	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Taiwan					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Philippines										x	x	x	x	x	x	x	x	x	x	x
Argentina										x	x	x	x	x	x	x				
Indonesia												x	x	x	x	x	x	x	x	x
Korea-South														x	x	x	x	x	x	x
Brazil															x	x	x	x	x	x
Egypt																x	x	x	x	x
Missiles																				
India			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Israel			(x)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
South Africa												x	x	x	x	x	x	x	x	x
Brazil												x	x	x	x	x	x	x	x	x
Pakistan													(x)	(x)	(x)					
Egypt														x	x	x	x	x	x	x
Taiwan														x	x	x	x	x	x	x
Argentina														(x)	x	x	x	x	x	x
Battle tanks																				
India	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Korea-North					(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
Israel													x	x	x	x	x	x	x	x
Argentina															x	x	x	x	x	x
Brazil																x	x	x	x	x
Korea-South																			x	x
Major fighting ships[c]																				
Korea-North	x	x					x	x	x	x	x	x	x	x	x	x	x	x	x	x
India				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Argentina							x	x	x	x	x	x	x	x	x	x	x	x	x	x
Brazil								x	x	x	x	x	x	x	x	x	x	x	x	x
Peru															x	x	x	x	x	x
Korea-South																x	x	x	x	x

[a]Years are for actual production (excluding assembly).
[b]Fighter aircraft include COIN roles, exclude trainers.
[c]Destroyers, frigates, corvettes and submarines
( ) uncertain data

Source: M. Brzoska and T. Ohlson, "Arms Production in the Third World: ar Overview," in M. Brzoska and T. Ohlson, eds., *Arms Production in the Thirc World*, Taylor & Francis, 1986a, p. 23.

TABLE 10. MAJOR SUPPLIERS OF CONVENTIONAL ARMS AMONG DEVELOPING COUNTRIES, 1979-1983

COUNTRY	VALUE OF TRANSFERS (Current U.S. Dollars in Billions)	PERCENTAGE OF WORLD TOTAL
Czechoslovakia	3,950	2.3
China	3,320	1.0
Poland	3,100	1.8
Korea, South	2,010	1.2
Romania	1,980	1.2
Korea, North	1,805	1.1
Israel	1,360	0.8
Yugoslavia	1,340	0.8
Spain	1,115	0.7
Bulgaria	840	0.5
Brazil	830	0.5

Source: U. S. Arms Control & Disarmament Agency, *World Military Expenditures and Arms Transfers*, U. S. Printing Office, Washington, D.C., 1985, p. 78.

Given the high costs and technical difficulties, many analysts have dismissed the possibilities of achieving total self-sufficiency in domestic arms production. However, producing weapons in the name of self-sufficiency is still the most important raison d'etre for transferring military technology in developing countries. (Brzoska and others, 1980, p. 87)

Indigenous military production is motivated mainly by the desire to reduce dependency on foreign arms suppliers (Klare, 1987, p. 1266). As one researcher states, "almost all of the countries that have embarked upon creating an arms-manufacturing industry have basically done this for political and security reasons. They wish to become more independent" (Pierre, 1982, p. 10).

However, another analyst observed that most of those developing countries with indigenous arms industries are generally dependent to a greater or lesser degree on imports of military technology--in the form of blueprints, technical assistance, specialized machinery and parts from the major developed countries. (Neuman, 1984, p. 162)

2. Economic Factors

Another motive for transferring military technology is that military technology and domestic arms production

benefit the economy of developing countries[6]. The main economic considerations of military technology transfer follow:

First, investment in the design and production of technologically advanced weapons in developing countries is seen as a means of creating a national technological infrastructure which later can be transferred to the civil sector. (Rivkin, 1968, pp. 61-78) Second, developing countries often suffer from excess capacity. Thus military production may have backward linkages and create demand for inputs produced by horizontally integrated civilian industrial systems. Finally, it is assumed that foreign exchange will be saved and employment created. (Deger, 1986, p. 154)

3. Technological Characteristics of the Arms Production

Establishing military-industrial complex for domestic arms production would have certain characteristics that force developing countries to transfer military technology (Lock and Wulf, 1979, p. 218):

1. Steadily increasing military research and development which result in ever more complex weapons systems.
2. A rising rate of weapon innovation and development which leads to rapid technological obsolescence, and

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[6]For more discussion of economic effects of military technology transfer to developing countries see: Saunders (1976, pp. 204-212), Lock and Wulf (1977, pp. 127-136), and Wionczek (1986, pp. 47-58).

3. Increasing complexity of weapon systems which reduces the possibility of "copying" and which allows for effective control of the technology by the licenser over a considerable period of time.

This dependence on military technology transfer and skills has become a significant factor in the global military trade.

C. SOURCES OF MILITARY TECHNOLOGY

A focus on licensed production of military products provides a more clear opportunity to examine the sources of military technology[7].

Table 11 shows that a small number of countries dominates the sale of military production licenses for major weapons systems. The United States of America (USA), the United Kingdom (UK), France (FR), the Federal Republic of Germany (FRG) and the Soviet Union (USSR) together account for nearly 85 percent of all licenses sold to developing countries during the 35 year period under consideration. With respect to the number of production licenses granted, the USA is the most diversified supplier. The USA has only nine recipient countries. This is the same number of licenses as for FRG and

[7]Licensed production is the most clear evidence of a military technology transfer. Although data concerning licenses are scarce, they are more available than data concerning other channels of military technology transfer. (Louscher and Salomone, 1987, p. 4)

the UK, and one fewer than France. The main recipient countries of the USA military technology are South Korea and Taiwan.

TABLE 11. MATRIX OF LICENSED-PRODUCTION PROJECTS FOR MAJOR WEAPONS, 1950-1984

	LICENSER									
	USA	UK	FR	FRG	USSR	ITALY	SPAIN	ISRAEL	OTHERS	TOTAL
BY LICENSEE										
Algeria		1			0.5[b]				0.5[b]	2
Argentina	2	1	1	3					1	8
Brazil		1	2	2		1			1	7
Chile	4		1				1		1	7
Egypt		3	3				1		1	8
India		8	5	3	7					23
Indonesia	1	2		2.5[b]			1		0.5[b]	7
Iran	4[a]									4
Israel	2		1							3
North Korea					5.5[b]				0.5[b]	6
South Korea	10					1				11
Malaysia				2						2
Pakistan		1		1					1	3
Peru	1					1	1			3
Philippines	1	1		1						3
Singapore		5		2						7
South Africa			4			2		1		7
Taiwan	5							2		7
Thailand			1	1						2
Others			1	1					1	3
TOTAL	30	22	21	17.5	13	5	4	3	7.5	123
BY WEAPON CATEGORY										
Aircraft	15	6	12	4.5[b]	5	3	3		3.5[b]	52
Armored Veh	3	2	4	1	4	1			3	18
Missiles	2	1	2	3	1			1		10
Ships	10	13	3	9	3	1	1	2	1	43

[a] All cancelled before start of production.
[b] Split in order to indicate two design countries

Source: M. Brzoska and T. Ohlson, "Arms Production in the Third World: An Overview," in M. Brzoska and Thomas Ohlson, eds., *Arms Production in the Third World*, SIPRI, Taylor & Francis, Philadelphia, 1986a, p. 26.

On the other hand, only India and North Korea use the military technology of the USSR. India is also an important market for British and French military technology. Israel not only produces weapons under license, but also has become a supplier of military technology such as transfer of ships to South Africa, and ships and missiles to Taiwan.

Most licenses, 42 percent are for aircraft production technology. While the USA, the UK and FRG dominate the supply of annual technology, the USA and France together account for 52 percent of the aircraft licenses. Not only are licenses for the production of armored vehicles less frequent, but also in general their production is relatively lesser.

D. THE VINTAGE OF TRANSFERRED MILITARY TECHNOLOGY

There is a lengthy time lag between military design and military production or between production start and initial deployment of the weapon systems in developing countries. This time lag is a measure of the technological level of the arms production process. Another such measure is the vintage of the technology used. (Brzoska and Ohlson, 1986a, p. 23) Generally, the Stockholm International Peace Research Institute (SIPRI) data show that mature technologies are often easier for developing countries to master and that they are

also less restricted by the original owners of the technology (SIPRI, 1987, pp. 270-282).

As shown in Table 12, such vintage comparison can be made for weapons produced under license. This shows that the technologies transferred are of varying vintages and that sophisticated and more or less obsolete technologies are being utilized side by side.

On the average and over time, for all weapons produced under license, the vintage gap has neither increased nor decreased. But there are marked differences when technological sophistication is singled out. When simple technologies are transferred, the vintage gap is very short. For instance, small patrol craft designs transferred from the Soviet Union to North Korea, or British and German designs to Singapore or American light-plane designs to Chile are of this kind. However, the vintage gap increases when more advanced technology is transferred (Brzoska and Ohlson, 1986a, p. 24)

TABLE 12. VINTAGE OF SELECTED ADVANCED MAJOR WEAPON SYSTEMS PRODUCED UNDER LICENSE

Licenser	Year of Initial Production in Licensing Company	Designation	License	Year of Initial Production in Licensee Country	Vintage Gap (Years)
AIRCRAFT					
USSR	1956	MIG-21	India	1966	10
Italy	1957	MN-326	Brazil	1971	14
FRG	1969	Bo-105	Indonesia	1976	7
France	1970	SA-315 Lama	Brazil	1979	9
UK	1971	Jaguar	India	1981	10
USA	1971	F-5E/F	South Korea	1980	9
France	1971	SA-342 Gazelle	Egypt	1983	12
France	1975	Alpha Jet	Egypt	1982	7
ARMORED VEHICLES					
USSR	1958	T-55	North Korea	1974	16
USSR	1971	T-72	India	1984	13
Switzerland	1974	Piranha	Chile	1981	7
USA	1974	M-109-A2	South Korea	1984	10
MISSILES					
USSR	(1958)	AA-2Atoll	India	1968	(10)
FRG	1960	Cobra-2000	Brazil	1975	15
UK	1968	Swingfire	Egypt	1978	10
France	1972	Milan	India	1984	12
SHIPS					
USSR/China	1958	Romeo Class	North Korea	1974	16
UK	1959	Leander Class	India	1966	7
France	1973	Batral Class	Chile	1980	7
FRG	1973	Type 209/3	Brazil	1982	9

( ) uncertain data.

Source: M. Brzoska and T. Ohlson, "Arms Production in the Third World: An Overview," in M. brzoska and T. Ohlson, eds., *Arms Production in the Third World*, SIPRI, Taylor & Francis, 1986a, p. 24.

Table 13 shows an approximation of the technological level that can be obtained by comparing start of design studies with deployment year for domestically designed weapons. This average time lag is about seven years for aircraft, about five years for armored vehicles, about six years for missiles and nearly three years for ships. The level of sophistication also proves to be the decisive factor. For more complex weapons the time lag is above these averages. (Brzoska and Ohlson, 1986a, p. 25)

From a purely strategic efficiency point of view, developing countries may receive optimum benefit from transferring the highly sophisticated military technology. However, since there is an increasing rate of obsolescence over time, increasing proportions being spent on new vintages will make the resource cost prohibitive. The macroeconomic cost of military technology must be considered too. (Deger, 1986, p. 179)

TABLE 13. DESIGN DEPLOYMENT TIME LAG FOR SELECTED ADVANCED MAJOR WEAPONS FOR DOMESTIC DESIGN

PRODUCER	DESIGNATION	DESIGN YEAR	DEPLOYMENT YEAR	TIME LAG (YEARS)
AIRCRAFT				
India	HF-24 Marut	1956	1964	8
Taiwan	AT-3	1975	1984	9
Brazil	AM-X	1977	(1987)	10+
ARMORED VEHICLES				
Israel	Merkava-1	1967	1978	11
South Africa	Ratel-20	1968	1976	8
India	Main Battle Tank	1974	(1985)	11+
MISSILES				
Israel	Shafrir-2	1962	1970	8
Israel	Gabriel-2	1969	1978	9
Brazil	MAA-1 Piranha	1975	(1984)	9+
SHIPS				
North Korea	Najin Class	1970	1976	6
Brazil	Niteroi Class[a]	1972	1979	7
India	Godavari Class[b]	1977	1983	6

[a] British design from 1970; first Brazilian built ships laid down in 1972.
[b] Stretched version of UK-designed Leander (Nilgiri) Class.
( ) uncertain data.

Source: M. Brzoska and T. Ohlson, "Arms Production in the Third World: An Overview," in M. Brzoska and T. Ohlson, eds.. *Arms Production in the Third World*, SIPRI, Taylor & Francis, 1986a, p. 25.

E. MEASURES RELATED TO CONTROL MILITARY TECHNOLOGY

The Coordinating Committee for Multilateral Export Controls (COCOM) includes Japan and all of NATO except Iceland. It is intended to act on a unified, allied level to halt the export of high tech gear to the Soviet block and China. (Gross, 1988, p. DS7) It maintains Military Critical Technology lists that are forbidden for sale to the East. (Appendix A).

This list includes most of the highly advanced electronic chip techniques, for they are integral parts of next-generation weapon systems that use astounding computational speeds and new storage and retrieval successes. (Roberts, 1988, p. 9)

There are some approaches to the control of the international transfer of arms and military technology. They are divided into unilateral, bilateral and multilateral measures. (Vayrynen, 1978/1979, pp. 91-92)

1. Unilateral Measures

These measures refer to decisions by one country to slow down it's arms sales, concessional or not, and aid. In this category of measures one must also include various licensing and other administrative arrangements which have been developed, especially in capitalist countries, to enhance

the ability of government to supervise the arms sales carried out by private arms manufacturers. However, unilateral measures are sufficient only in a situation in which one supplier has a monopoly in the international arms market. As this seldom happens, and definitely not recently, bilateral and multilateral arrangements are also needed.

2. Bilateral Measures

These measures mean a decision by any two suppliers to agree upon joint principles and arrangements to restrict the transfer of arms and military technology abroad. These restraints are naturally more effective if these nations account for a substantial share in the arms market.

3. Multilateral Measures

These measures can be divided into two principal types. Those carried out by international organizations, either regional or international, and those concluded between governments outside this kind of organizational framework.

Thus far, only the control measures on the supplier side have been discussed, but control measures can be taken at the recipient end also by importers of arms deciding to apply restrictions. They may be taken unilaterally, when a nation decides, often for economic reasons, to stop or reduce the import of arms. On the other hand, they may be taken

bilaterally by two rival countries trying to reach an agreement not to import weapons or exclude certain types of arms from imports. Finally, multilateral restrictions may take place, for example, through regional agreements to restrict or abolish the inflow of arms into the region concerned. (Vayrynen, 1978/1979, p. 92)

By considering these two dimensions of control arrangements, it is possible to develop a sixfold typology represented by Table 14.

TABLE 14. RESTRAINTS ON TRANSFER OF MILITARY TECHNOLOGY

MEASURES CONTROL	UNILATERAL MEASURES	BILATERAL MEASURES	MULTILATERAL MEASURES
Export Control	Unilateral export restraints	Bilateral agreements between exports	Multilateral agreements between exports
Import Control	Unilateral decisions to restrict imports	Bilateral agreements to restrict imports	Multilateral agreements to restrict imports

Source: R. Vayrynen, "Curbing International Transfers of Arms and Military Technology," *Alternatives*, IV, 1978/1979, p. 92.

F. STRATEGIES FOR MILITARY TECHNOLOGY TRANSFER

"Path" and "engineering" are the two major strategies used by developing countries to acquire military technologies.

1. Path Strategy

In the path strategy, military technology transfer moves through several steps. The following suggestive steps are the learning states which are likely in the transfer of military technology[8]. Any country may be at different steps with regard to different technologies. For instance, Turkish fighter-bomber production is more dependent upon foreign design and components than is shipbuilding.

a. *Step One: Maintenance and Repair of Transferred Systems*

The recipient country develops a repertoire of maintenance capabilities. It learns how to repair, maintain and rebuild foreign equipment. Domestic civilian industries transfer this type of information or foreign suppliers provide it to promote domestic skills.

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[8]The path strategy of military technology transfer has been discussed in various forms and combinations in the defense literature, for example, see: Louscher and Salomone, 1987, pp. 3-4), Church (1984, p. 10), and Tuami and Vayrynen (1982, pp. 118-120).

b. *Step Two: Assembly of Subsystems from Imported Components*

At this step, manufacturing capabilities are expanded to domestic assembly under license of component packages provided from major industrial suppliers. Licensed assembly in the military production is almost totally dependent on foreign design and foreign components.

c. *Step Three: Final Production of the Weapon System and Production of Basic Components*

At the third step, the recipient country develops a capability to manufacture basic components of a weapon system designed by a supplier, as well as to provide final assembly of the weapon system. Foreign technical assistance is provided for the establishment organization and operation of facilities to produce or to assemble components, or end items of foreign designed equipment.

d. *Step Four: Production Using Imported Design*

Domestic arms production starts by using imported weapon designs in the fourth step. Also, production can be accomplished through reverse engineering of foreign weapons. The recipient country develops an engineering ability to modify technology designed by a supplier. This capability, combined with the production knowledge, industrial organization, and technical skills acquired through licensing,

coproduction, foreign design assistance and joint venture permit the production of weapon systems.

e. *Step Five: The Capability to Design Weapon Systems Indigenously*

This step assumes that the knowledge and capabilities to produce a significant number of major components exists. Although there is minimal dependence on foreign sources for design, organizational knowledge, technical skills, or components, critical technical and organizational skills for end item assembly are required.

f. *Step Six: Production Based on Local Research and Design of New System*

At the sixth step, through transferring military technology, a country achieves capability not only to design, but also to manufacture weapon systems using all domestic components. This stage marks true self-sufficiency in military production, and it is the ultimate objective of military technology transfer process.

2. Engineering Strategy

The view that military technology transfer should follow the steps that lead to self-sufficiency in military production is still predominant among developing countries. However, especially with respect to latter steps, there are

two main reasons that undermine path strategy. (Brzoska and Ohlson, 1986b, p. 283)

First, the developments in military technology are so fast that even many developed nations which have outlays on research and development cannot afford to keep up with them. Since the rate of technological obsolescence is accelerating, there is a need for more frequent replacement of products and for product improvement programs. As a rule, beyond a certain point the technical problems of import substituting are substantial.

Dependence on imported know-how and materials normally increases with the degree of sophistication of the weapons. Attempts to increase the domestic content per unit of output also often lead to a steep rise in costs.

Second, the concept of self-sufficiency has lost much of its meaning during the past two decades. This is true even for most of the developed countries. For instance, Japanese, German, and Swedish aircraft have engines that are designed in other countries. Only arms producers in the United States and the Soviet Union managed largely to avoid having to use foreign components.

Therefore, after creating an adequate industrial and technological base, a developing country may replace the path strategy with engineering strategy. The two types of engineering strategy are "add-on engineering" and "add-up engineering".

> Add-on engineering refers to the adaptation of an existing weapon system to specific needs by changing components, adding features or taking them away, and trying to incorporate as many indigenous parts as possible. (Brzoska, 1986, p. 206)

In other words, it is an updating, upgrading, improving and an adapting of existing weapons technologies (Matthews, 1988, p. 12). In the early 1960s, South Africa first produced French AML vehicles under license. Then, since the early 1980s, by using add-on engineering strategy, it has produced the Eland armored cars. Israeli combat aircraft Kfir and Nesher, are also the result of this strategy using French Mirage blueprints. The Shafrir missile is based on the Sidewinder. The Egyptian Early Bird missile is based on the Soviet SA-2; and the October class fast attack craft in the Egyptian Navy largely resembles the Soviet Komar Class. (Brzoska, 1986, p. 284)

On the other hand,

> Add-up engineering is more demanding in terms of technical know-how and previous production experience...The idea is to raise sources of supply throughout the world to integrate imported components into a new and functioning weapon system (Brzoska, 1986, p. 284).

Brazilian armored vehicles from Engesa, aircraft from Embraer, South Korean howitzers and ships, and Taiwanese missiles and artillery are designed by using add-up engineering transfer strategy. This strategy can also be used with respect to "simpler" military products such as the production of jeeps and trucks in the Philippines. (Brzoska, 1986, p. 284)

Implementation of add-on and add-up engineering strategies require a certain level of technological base. Therefore, some channels of technology transfer should be used to acquire that capacity.

IV. CHANNELS OF MILITARY TECHNOLOGY TRANSFER

Throughout the literature, the channels of technology transfer have been classified according to different criteria[9]. For the purpose of this study, we have classified them according to the degree of participation of the recipient country in the transfer process and the existence of a continuous relation over time, involving a certain level of division of labor and risk-sharing between the supplier and the recipient countries. According to this criterion, military technology transfer channels can be classified under four broad categories.[10]

1. Licensed production agreements
2. Coproduction agreements

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[9]For those distinctions see: Spencer (1967, pp. 157-159), Robock and Calkins (1980, pp. 6-7), Liebrenz (1982), White (1983, pp. 16-25), and Office of Industrial Innovation (1986, pp. 27-40).

[10]Other channels of military technology transfer will not be discussed separately in this study for three reasons. First, channels such as training, education and consulting are often included under the heading of "show-how" in the agreements of the above-mentioned four categories. Second, although military presence in one country has impact of upgrading technical potentials, for the purpose of this study, it is not a relevant transfer channel. Finally, as a result of economic considerations, military assistance programs are no longer as important transfer channels of military technology as before.

3. Joint venture agreements

4. Foreign design assistance

Although military technology transfer has beneficial effects, the costs are extremely high. In order to lessen the outflow of foreign currency required, some arrangements have been made. The term "offset" is used, in this study, as a generic word to refer to all compensatory arrangements practiced in the transfer of military technology.[11] Therefore, each of the above mentioned channels may be thought of as a direct offset. Moreover, these mechanisms are not mutually exclusive and military technology transfer agreement may incorporate elements from each of them[12]. For instance, the Turkish offset agreement with General Dynamics is a joint venture in nature, but it constitutes the coproduction of 160 F-16 C/D combat aircraft too.

While licensed production, coproduction, joint venture and foreign design assistance agreements explicitly entail

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[11]For the detailed discussion of offsets, see: Welk (1984, pp. 20-23), Brzoska and Ohlson (1985, pp. 130-135), Neuman (1985, pp. 189-213), Church (1984, pp. 9-13), and Hammend (1987, pp. 173-185).

[12]In the literature, the terms "offset", "coproduction", "licensed production", "joint venture", and "foreign design assistance" are used interchangeably. For example, see: Neuman (1985, pp. 183-185), and Louscher and Salomone (1987, p. 3).

the transferring of military technology to the recipient country, other major offset types--subcontracting and counter-trade may not (Appendix B). The latter two are less likely to encourage the technological advancement of the recipient. Therefore in this study, only the former four types of offsets are discussed as channels of military technology transfer.

A. OFFSETS

Offsets are commercial transactions in which the buyer demands, as a condition of the sale, that the seller compensate the buyer through a variety of nonmonetary means. (Hammend, 1987, p. 175)

According to the U.S. Department of Defense, the first military offset programs authorized the coproduction of the F-104 aircraft and HAWK air defense system in Europe. Over time, the demand for military offsets which began in the developed countries (i.e., NATO, Japan, Australia, and Switzerland) spread to the developing nations (i.e, Korea, Israel, Taiwan, Singapore, India, Pakistan, Thailand, Argentina, the Philippines, Brazil, and Turkey). (Welk, 1984, p. 21)

The existence of military offset programs stems from the inelastic demand for military hardware among governments, the need to purchase equipment abroad, and the high prices of these goods (Welk, 1984, p. 21). In order to maintain and exercise their sovereignty, governments feel the need to have a standing military force that is prepared to defend the integrity of it's borders.

Most developing countries do not have economies large enough to support the country's arms industry needed to satisfy the demand of defense. Therefore, offsets are used for the targeted development of military industry and enhancement of domestic capabilities by the purchasing countries that are facing *exchange earnings*.

Brzoska and Ohlson (1985, p. 132) point out that offsets may include:

1. The transfer of military technology
2. Subcontracting in the purchasing country for components and spares for the weapon
3. The right to market the weapon on behalf of the supplier
4. Repair and maintenance contracts for weapons, and imports of other industrial goods from the recipient by the supplying country.

In offset arrangements, the offset is customary to split into two groups--direct and indirect. Direct offsets are those which are directly related to the product purchased, such as its development, assembly or the production of its components. On the other hand, indirect offsets are contractual arrangements that involve goods and services unrelated to the exports referenced in the sales agreement (Neuman, 1985, p. 185).

The sale of F-16 C/D fighters to Turkey presents a classic case study in the way offsets work and the advantages that occur to each party. The Turkish F-16s will be produced in part by a jointly-owned aircraft manufacturing plant being built in Turkey by a Turkish aerospace firm and by General Dynamics. It will coproduce 160 General Dynamics F-16 combat aircraft. The total value of the project was $4.2 billion, $3 billion was provided by FMS credits and the balance by the Turkish government.

The direct offset commitment, which included the establishment of a joint venture manufacturing plant to assemble the F-16 and produce its components. General Dynamics and it's major sub-contractor, General Electric were to aid the capitalization of the plant by the

provision of 49% of the funds required, worth $70 million. As a part of the agreement, General Dynamics has undertaken to export any excess component production from the Turkish plant. (U.S. General Accounting Office, 1984, p. 3, 7)

This is an example of a direct offset, similar to arrangements made between U.S. and European firms in NATO for a number of years. The aircraft or important subsystems of it are manufactured jointly in the buyer's country to help offset the cost of the buy by providing employment, technology transfer, and investment in new plants and equipment. Thus, Turkey will literally acquire an aircraft industry.

The other aspect of the agreement is the indirect offset commitment agreed to by General Dynamics--$1.27 billion. This had to be achieved within 10 years. Otherwise the company would have to pay a 1.5% non-fulfillment penalty. (Gavin, 1986, p. 169)

The indirect offset commitment was split into two categories. Group 1, which included capital investment, joint ventures and technology transfer, was to account for 10% of the total. Group 2, which includes the purchase for

export of Turkish goods and services accounting for 90% of the commitment.

General Dynamics has become responsible for marketing a complex list of Turkish products including tourism, power projects, and marble. Wasting effort and resources on a low cost venture will not significantly reduce the offset commitments. Thus, General Dynamics is in the business of economic development. It plans, designs, develops and finances a product, industry, or real estate development that provides Turkey with the cash to pay General Dynamics for it's product. The multiplier effect on both the seller and the buyer are of great potential and create a situation in which the ideas, technology, and marketing skills of a U.S. defense contractor are placed at the service of a developing country that has little of these, and in many cases, neither the success nor influence to obtain them readily. The result may be a serendipitous arrangement of mutual advantage.

For the purchasing country, offset arrangements bring important benefits; they lessen the outflow of foreign currency, maintain or create domestic employment, lead to the acquisition of modern technology, create service

capability for high technology equipment and assist in local economic development. It is also clear that it serves the interests of the supplier country by creating a healthy interdependence on its weaponry, increasing it's exports and promoting ties between the supplier and the purchasing countries. (Church, 1984, p. 10)

B. LICENSED PRODUCTION

A license is commonly used to describe situations where:

> The owner of certain statuary rights in the technology... grants permission to another party to exercise some of those exclusive rights held by the owner of the technology (Office of Industrial Innovation, 1986, p. 28).

Licensing agreements generally include a series of provisions regulating the rights and obligations of both recipient and supplier with regard to use of the technology (White, 1983, p. 30). The oldest method of international production of weapon systems that are developed in another country is the bilateral licensing agreement. (Defense Systems Management College, 1981, pp. 4-14)

Moreover, these agreements have become very common in international transfer of military technology, both among developed countries and between developed and developing

countries. Highly competitive arms market has stimulated these agreements. Because many arms receivers usually prefer license purchases as a channel of military technology transfer. (Brzoska and others, 1980, p. 15)

As indicated in Table 15, the United States is the primary distributor of military technology. In the one-and-one-half decade period of 1971-1985, the U.S.A. provided weapon production licenses to seven different developing nations. The types of major weapons licensed included four licenses for helicopters, fast attack craft and patrol craft respectively, and three licenses for production of trainers and fighters respectively.

While United Kingdom, France, and West Germany actively provide licenses to developing nations, they do not do so at a level equalling the United States.

United Kingdom provided for ten different major weapon systems to eight different developing recipients. France issued licenses for seven different major weapon systems to eight different developing countries. West Germany provided licenses for ten weapon systems to eight different developing countries. The Soviet Union supplied licenses

for ten weapon systems to two different developing countries.

Among the fifteen suppliers of licenses to developing countries, some of the suppliers themselves are often categorized as developing nations. Brazil, Israel and China are categorized as developing nations.

Quite instructive is the competition among suppliers. While the U.S.A. is again the primary supplier of trainer production licenses, it should be noted that eight different nations provided such licenses. Five nations provided licenses to produce fighters and patrol crafts. Significant competition existed among armored personnel carriers, fast attack craft, transport aircraft, helicopters, frigates, submarines and anti-tank missiles. Nine suppliers competed in sales of licenses among these types of weapons.

Table 15 also indicates that there are basically three types of military technology suppliers competing in the developing countries.

1. The major suppliers include the United States of America, Great Britain, France, and West Germany

2. The Soviet Union followed by Italy, Switzerland and Israel are significant suppliers of licenses

3. Austria, Spain, Brazil, China and Sweden are minor suppliers of military technology.

The major suppliers each provided over seven different weapons types licenses. The licenses issued by the middle group varied from three to seven weapon types. The minor licensers provided no more than two different weapon types licenses.

The number of licenses for various equipment categories held by developing world nations is identified in Table 16. The table reveals that among the twenty-one developing countries, aircraft are the systems most commonly produced under license. There are 15 agreements to produce helicopters, 13 fighters and trainers agreements, four transport aircraft agreements, three light plane agreements, and two counter-insurgency aircraft agreements.

Sea equipment ranks second with licenses for 38 such systems. There are licenses for 18 ground equipment systems. Eight models of missiles and one radar system are produced under license among the developing nations.

TABLE 15. DEVELOPING COUNTRIES' LICENSE ACTIVITY OF MAJOR SYSTEMS, BY SUPPLIER AND WEAPONS TYPE, 1971-1985

Countries / Weapons	Austria	Brazil	China	France	FRG	Israel	Italy	Spain	Switzerland	Sweden	USA	USSR	UK	Number of Licenses per Weapon	Number of Suppliers per Weapon
AIR															
Trainers		1		2	1		3	1	1	1	3			13	8
Fighters				2							3	5	3	13	5
Helicopters				8	3						4			15	3
Light Planes											2		1	3	2
Counter-Insurgency Aircraft							1						1	2	2
Transport Aircraft					1			1			1		1	3	4
GROUND															
Armored Personnel Carriers	1						1		2			1		5	4
Main Battle Tank												3	1	4	2
Medium Tank			1											1	1
Armored Cars				2										2	1
Towed Howitzer	1										1			3	2
Infantry Combat Vehicles					1							1		2	2
Self-Propelled Howitzers											1			1	1
SEA															
Fast Attack Craft					2	2					4		1	9	4
Frigates					1		1						4	6	3
Petrol Craft					3						4		5	12	3
Submarines			1		2				1					4	3
Destroyers													1	1	1
Landing Craft				1							1		2	4	3
Landing Ships				2										2	2
MISSILE & RADAR SYSTEMS															
Anti-Tank Missiles				2	2								1	5	3
Air-to-Air Missile												1		1	1
Ship-to-Ship Missile						2								2	1
Radar Systems									1					1	1
NUMBER OF LICENSES PER COUNTRY	2	1	1	19	17	3	6	2	5	1	25	11	20		
NUMBER OF WEAPONS PER COUNTRY	2	1	1	7	10	2	4	2	4	1	10	5	10		

Source: Prepared from M. Brzoska and T. Ohlson, *Arms Transfers to the Third World 1971-85*, SIPRI, Oxford University Press, 1987, pp. 282-286.

The United States' licenses have been granted mainly for aircraft and sea weapon systems, the French military industry has been mainly involved in helicopters and guided missiles. British and West Germans have been particularly active in shipyards.

Table 16 also indicates the relative number of weapon types licenses used by twenty-one developing countries who produce major systems under such agreements. As indicated, India has the most diverse licensed production plans. Eleven different systems are planned for production under 21 license agreements in India. Seven fighter types, two kinds of helicopters and transport aircraft were or are planned for production in India under such agreements. India has obtained licenses for two different main battle tanks, and anti-tank missiles, an armored personnel carrier, an infantry combat vehicle, a frigate, a submarine, an air-to-air missile and a radar system.

TABLE 16. NUMBER OF MAJOR WEAPON SYSTEMS LICENSES IN DEVELOPING COUNTRIES BY EQUIPMENT CATEGORY, 1971-1985

Countries / Weapons	Algeria	Argentina	Brazil	China	Egypt	India	Indonesia	Israel	Korea, North	Korea, South	Madagaskar	Malaysia	Mexico	Nigeria	Pakistan	Peru	Philippines	Singapore	South Africa	Taiwan	Thailand	Number of License Receivers	Number of Licenses per Weapon
AIR																							
Trainers			1	3	3										1		1		2	2	1	8	13
Fighters						7				1									2	2		5	13
Helicopters	1	1			3	2	5			1										1	1	1	7
Light Planes										1							1			1		3	3
Counter-Insurgency Aircraft :			1																			1	2
Transport Aircraft						2	1	1														3	4
GROUND																							
Armored Personnel Carrier		1		1		1				1				1								5	5
Main Battle Tank						2			2													2	4
Medium Tank		1																				1	1
Armored Cars																			2			1	2
Towed Howitzer			1							2												2	3
Infantry Combat Vehicle	1					1																2	2
Self-Propelled Howitzer										1												1	1
SEA																							
Fast Attack Craft								1		2								3	1	2		5	9
Frigates		1	2			1									1	1						5	6
Patrol Craft	2			1			1	1		1		1	2			1		2				9	12
Submarines		1	1			1			1													4	4
Destroyers		1																				1	1
Landing Craft										1	1							2				3	4
Landing Ships				1																	1	2	2
MISSILE RADAR SYSTEM																							
Anti-Tank Missiles			1		1	2									1							4	5
Air-to-Air Missile						1																1	1
Ship-to-Missile																				2		1	2
Radar Systems						1																1	1
Number of Licenses per Country	2	7	8	6	7	21	7	3	3	11	1	1	2	1	3	2	2	7	7	10	3		
Number of Weapons per Country	1	7	7	4	3	11	4	4	2	9	1	1	1	1	3	2	2	3	4	6	3		

Source: Prepared from M. Brzoska and T. Ohlson, ***Arms Transfers to the Third World 1971-85***, SIPRI, Oxford University Press, 1987, pp. 282-286.

Among the recipients in the developing countries, clear patterns appear. Many recipients use multiple suppliers for licenses. For example, India utilized five different industrial license suppliers to produce weapons systems in eleven different categories. Other major multiple source users include Brazil, Indonesia, Pakistan, Argentina, Chile, Singapore, and South Africa. While Taiwan and South Korea are highly involved in license production, they rely on limited sources. North Korea, Peru, Algeria, and Malaysia use only two sources for licenses. Single source recipients in the developing countries include Nigeria, Mexico and Madagascar.

In the last one-and-one-half decades, licensed production has expanded in Turkish military industry's role in the manufacture of the G-3, MG-3 infantry weapons, ammunition, missiles and artillery.

All of the above data signal the growing phenomenon of transfer military technology to the developing countries through the instrument of license.

C. COPRODUCTION

The U.S. Department of Defense (1974, p. 2) defines coproduction as:

> ...any program wherein the U.S. Government...enables an eligible foreign government, international organization, or designated commercial producer to acquire the know-how to manufacture or assemble, repair, maintain and operate, in whole or in part, a specific weapon, communication or support system, or an individual military item.

The more sophisticated the weapon system is, the higher usually the share of foreign parts and know how. Multilateral and bilateral coproduction forms are arranged either vertically or horizontally. (Tuami and Vayrynen, 1982, p. 139)

Vertical coproduction means that the industry of the purchasing country not only produces components for the particular weapon system bought by the country, but also produces those components for all the systems which are constructed abroad. These components can be totally or partially indigenous.

Horizontal coproduction, in turn, contains only the production of components for those weapons acquired by the country herself. It is almost self-evident that vertical coproduction is more profitable to the producer of the components than horizontal because in the vertical arrangement, the factors reducing unit costs are more

visible. Also from the standpoint of the seller, the vertical version would be more useful because the cost reduction is also beneficial to him. The economic factor may be the main explanation of the fact that vertical coproduction projects have been recently on the increase.

The extent of U.S. coproduction projects abroad can be obtained from Table 17 which gives the number of projects by leading arms manufacturers as well as their distribution between developed and developing countries.

A number of conclusions can easily be drawn from Table 17. First, practically all the corporations on the list are aircraft manufacturers which seem to be most internationalized both *in terms of* exports, direct investments and coproduction patterns. There are more joint projects with governments and manufacturers from developed rather than developing countries. Japan and Italy are very central partners; U.S. aircraft manufacturers have concluded altogether 40 joint projects with them.

TABLE 17. UNITED STATES MILITARY COPRODUCTION PROJECTS ABROAD

	Developed Countries	Developing Countries	Total
General Electric	12	-	12
Bell	8	2	10
Northrop	3	2	5
Sikorsky	5	-	5
Cessna	-	4	4
Hughes	3	1	4
Pratt & Whitney	4	-	4
Boeing	4	-	4
Lycoming	3	1	4
Ratheon	3	-	3
General Dynamics	2	-	2
Lockheed	2	-	2
Pazmany	-	2	2
McDonnell Douglas	2	-	2
All Others	7	8	15
TOTAL	58	20	78

Source: Helena Tuami and Raimo Vayrynen, *Transnational Corporations, Armaments and Development*, St. Martin's Press, 1982, p. 136.

D. JOINT VENTURE

Joint venture can be defined as a development and manufacturing of military systems involving more than one military-industrial firm and significant level of interfirm

cooperation in research, design, production and marketing, as well as significant contributions by all partners to develop funds and risk capital. (Mowary, 1987, p. 3)

Recently, an increasing number of new investments have been joint ventures involving ownership between local and foreign partners. There are various factors contributing to the growth of joint ventures as a transfer channel of military technology. Developing countries may pass legislation either prohibiting total foreign ownership or making incentives conditional upon certain degrees of local ownership. On the other hand, technology suppliers have become increasingly aware of the benefits of sharing ownership with local partners. These include land, capital, trained personnel and familiarity with local markets. (Kaynak, 1985, p. 163)

The two types of joint ventures are equity and contractual (White, 1983, pp. 18-24).

Legislation of the recipient countries encourage the formation of equity joint ventures on the basis of requirements related to the share of equity in local hands and its effects on the decision making system of the enterprise.

In general, the participation share of local party in joint venture is at least 51 percent. In the Turkish joint venture example, the Turkish Aerospace Industry, Inc (TUSAS) holds 51 percent of capitalization as a participation share. The foreign partner, General Dynamics, with its major subcontractor, General Electric, are to aid the capitalization of the plant by the provision of 49 percent of the funds required.

Equity joint ventures normally imply the combined transfer of other resources of the foreign enterprise, such as capital and management, so that they cannot be considered as a specific mechanism exclusively for technology transfer.

However, equity joint ventures have an important incidence on the way and conditions in which technology can be transferred from abroad. The main implications concern (White, 1983, p. 19):

1. The strategies of technology suppliers--i.e. transnational corporations and other firms vis a vis the supply of technology through this mechanism,

2. The procedures of technology transfer and renumeration,

3. The capacity of the military-industrial firm to ensure an effective transfer.

The other kind of joint venture is contractual. Transfer of technology could be the central, basic objective of these contracts, or just an aspect of a more complex arrangement. But the essential characteristic of contractual joint ventures is that there is a complete de-linking of the resource transfer and the equity ownership of the foreign supplier of technology; and that the foreign suppliers are granted rights for only a specified period of time. In this sense, they appear in principle to be a more unpackaged way of technology transfer than the equity based arrangements. (White, 1983, p. 23)

The experiences of the Arab Organization of Industrialization (AOI)[13] exemplify the joint venture arms projects to transfer military technology in developing countries.

The agreements negotiated with Western governments and arms industries followed a basic pattern: the AOI created a subsidiary company which represented a partnership with the supplier. The chairman of the subsidiary was an Arab, while the managing director came from the foreign partner.

[13]For more information on AOI see: Vayrynen (1979, pp. 66-79). The AOI also sometimes referred to as the AMIO-The Arab Military Industries Organization.

The supplier agreed to deliver technical assistance and training, as well as some initial equipment over the period of the agreement. In each case, the AOI had the majority interest in the subsidiary company (Vayrynen and Ohlson, 1986, pp. 110-112). Table 18 lists the characteristics of the initial AOI joint ventures with Western companies.[14]

E. FOREIGN DESIGN ASSISTANCE

Foreign design assistance has become an important type of technology transfer. Some cases of design assistance are listed in Table 19.

The supplier country transfers information that may be classified and thus difficult to obtain for designing an indigenous weapon system.

These alternative channels of military technology transfer are not clearly differentiated and thus often overl.. In this sense, there are two main points to be considered in the selection of the channel. (White, 1983, p. 36) First, generally, the terms and conditions

[14]The future of these projects looked dim, when, in 1979, Saudi Arabia and the other Gulf AOI members decided to stop funding AOI activities and leave the AOI. The main reason, it was argued, was that the Camp David Peace Treaty between Israel and Egypt directly contradicted the purpose of the AOI.

TABLE 18. INITIAL AOI JOINT VENTURES

Joint Venture	Established	Ownership	Product	Comment	Fate of Project After 1979
Arab-American Vehicle Co. (AAV)	1978	AOI 51% American Motor Co. 49%	CJ-6 jeeps	Some to be equipped with Swingfire anti-tank missiles; contract value $30-35 million; 12,000 jeeps annually	Continued
Arab-British Dynamics Co. (ABD)	1977	AOI 70% British Aerospace 30%	Swingfire anti-tank missiles	Contract value $80 million	Continued
Arab-British Helicopter *Co. (ABH)	1978	AOI 70% Westland 30%	Lynx helicopters	Planned procurement of 280; initial contract for 50 worth $110 million	Cancelled; the company now assembles Aerospatiale Gazelle helicopters
Arab-British Engine Co. (ABE)	1978	AOI 70% Rolls-Royce 30%	Gem engines	750 turbo-shaft engines to power the Lynx helicopters; contract value $115 million	Cancelled; the company now assembles Turbomeca Astazou engines for the Gazelles
Arab-French Aircraft Co. (AFA)	1978	AOI 64%,* Dassault-Breguet 36%,*	Alpha Jet trainer/ground attack aircraft	Planned procurement of 160; to be followed by assembly of Mirage 2000	Cancelled, but continue in modified form since 1981
Arab-French Engine Co. (AFE)	1978	AOI 85%,* SNECMA 15%*	Turbomeca-SNECMA Larzac turbo-fan engines for the Alpha Jet	To be followed by the SNECMA M53 powering the Mirage 2000	Cancelled, but continue in modifed form since 1981
Arab Electronics Co.	1978	AOI 70%, Thomson-CSF 30%	Military electronics	Only major AOI plant outside Egypt; situated at Al Kharj in Saudi Arabia; to produce avionic equipment for AOI-produced aircraft	Probably discontinued

*These percentages represent the current shares. At the time of AOI's dissolution in 1979, the shares were not fixed. Planned shareholding of Dassault-Breguet and SNECMA was reportedly to have been 25 percent.

Source: R. Wayrynen and T. Ohlson, "Egypt: Arms Production in the Transnational Context," in M. Brzoska and T. Ohlson, eds., *Arms Production in the Third World*, SIPRI, Taylor & Francis, 1986, p. 112.

TABLE 19. SELECTED CASES FOR FOREIGN DESIGN ASSISTANCE

Country	Designation	Description	Design Year	Design Assistance From
Argentina	IA-27 Palqui	Fighter	1946	Dewoitine, France
Argentina	IA-33 Palqui-2	Fighter	1950	Kurt Tank, FRG
Egypt	HA-200	Trainer	1960	FRG, Spain
South Africa	Whiplash	Air-to-Air Missile	1964	FRG
Argentina	TAM	Medium Tank	1974	Thyssen, FRG
Taiwan	AT-3	Trainer	1975	Northrop, USA
Argentina	IA-63 Pampa	Trainer	1977	Dornier, FRG
Brazil	V-28 Type	Frigate	1978	Marine Techaik, FRG
Taiwan	Chin Freng	Surface-to-Surface Missile	(1978)	Israel
Thailand	Thaiang Type	MCM	1978	Ferrostaal, FRG
India	Vicram Class	Corvette	1979	The Netherlands
South Korea	Rokit	Main Battle Tank	1983	General Dynamics

( ) uncertain data

Source: M. Brzoska and T. Ohlson, "Arms Production in the Third World: An Overview," in M. Brzoska and T. Ohlson, eds., *Arms Production in the Third World*, SIPRI, Taylor & Francis, 1986a, p. 27.

negotiated within each form are more important than the forms as such. Second, the correct choice of the channel depends on the type and size of the weapon project, internal capacity of the recipient military-industrial firm, and a constellation of external factors, ranging from legislation to external finance.

From the efficiency point of view, generally, it is assumed that joint ventures are better than other transfer channels. The first reason is that the technology supplier, who shares the risks and profits of the project, will be directly interested in the success of the enterprise. The second reason is that there is a continuous association in responsibility and division of labor between the partners. (White, 1983, p. 21)

Through the network of licenses, coproduction, joint ventures and foreign design assistance agreements, today's military technology receiver becomes a producer.

V. THE RESULTS OF MILITARY TECHNOLOGY TRANSFER

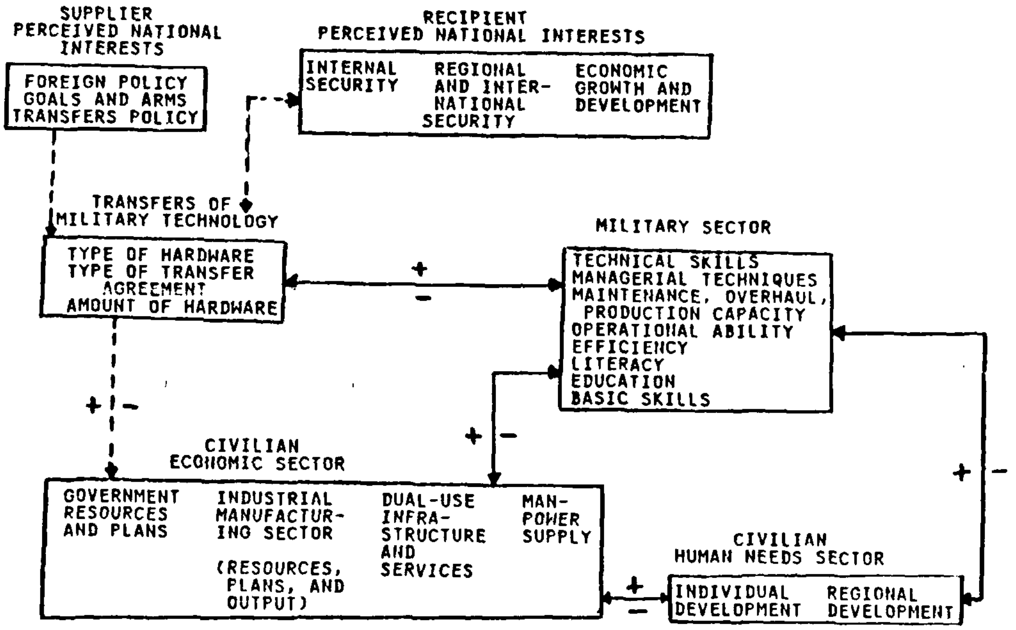
The transfer of military technology to developing countries affects the military and civilian sectors. Moreover, the transfer has benefits and drawbacks to both supplier and receiver countries.

A. EFFECTS ON THE CIVILIAN SECTORS OF THE SOCIETY

Neuman and Harkavy (1979, pp. 234-237) developed a hypothetical model that shows how military technology transfer connects with the rest of society in developing countries (Figure 4).

The transfer process begins when the policy makers of a developing country decide on the basis of their available resources, and security and development goals, to obtain military technology abroad. After negotiations with the supplier country are complete and the requirements of the buyer country established, the formal transfer of military technology begins. Even before receiving the military technology, the military derives benefits from this transfer such as increased technical, management, and

language training; perhaps higher morale; travel abroad; larger budget outlay; and so on.



Note: The direction of any particular arrow and the value of its net flow (positive or negative) may change from time period to time period.

Source: S. G. Neuman and R. E. Harkavy, "Transfers and Economic Development," in S. G. Neuman and R. E. Harkavy, *Arms Transfers in the Modern World,* Praeger Publishers, 1979, p. 235.

Figure 4. Effects of Military Technology Transfer on Civilian Sectors of the Society

However, as the military technology begins to arrive, the picture becomes more complicated. Negative spinoffs affect some parts of society, although this can vary with the amount and kind of military technology received. For example, increased military demand may create a drain on already scarce human and natural resources, disrupt civilian, and overload insufficient communications networks and infrastructure facilities. On the other hand, some civilian sectors may derive many unanticipated benefits from these military activities. The housing, communications, transportation, educational, and health sectors are often the first to be mobilized to meet military requests associated with imported military technology.

Bases must be built to store, operate and maintain new weapons. Housing, roads, railroads, parts, telephones, electricity, water supplies, schools, and hospitals must be established to serve them. In turn, these bases often located in remote regions of the country, stimulate the growth of satellite cities which leads to further change.

The industrial sector also becomes involved. A longer, better educated military creates a larger, more

sophisticated domestic market. In addition, more food, uniforms, medicines, supplies, and technical equipment (ranging from batteries to buses) must be purchased by the military from the civilian economy. In this way, not only profits, but large amounts of technical and management know-how, are transferred into the civilian sector. Thus, local manufacturers gear up their production lines for a bigger market and are encouraged to produce a better product.

As the capabilities of the country increase, feedback from the civilian sector influences arms-procurement policies. Security and development goals change as the country grows; competing pressure groups vie for foreign-exchange resources; domestic industries and educational institutions provide more of the needed resources so that foreign military equipment and training become less necessary, and the circle is complete. (Neuman and Harkavy, 1979, p. 236)

B. EFFECTS ON THE MILITARY

It is becoming increasingly evident that military technology is a powerful factor in shaping the military doctrines. Military technologies and doctrines mutually

reinforce each other within a political environment. (Tuami and Vayrynen, 1982, p. 254)

When developing countries transfer military technology at the same time, they also acquire specific modes of organization and military doctrines from the developed countries.

> This is not necessarily bad; however, it cannot help but confuse military planning and raise questions about operational effectiveness. Possession of a new technology is not equivalent to the possession of a new military capability. This technology must be incorporated into the existing military structure. If it cannot, then the structure must be changed (which could entail considerable disruption) or the technology should be abandoned. (Moodie, 1979, pp. 41-42)

As a result of military technology transfer, mainly the structure of the armed forces of a country ought to change toward professionalized organization in order to use the technological development efficiently.

C. ADVANTAGES AND DISADVANTAGES OF MILITARY TECHNOLOGY TRANSFER

Military technology transfer has both benefits and drawbacks for recipient countries as well as supplier countries.

1. Recipient Country

Through the technology transfer process, the recipient country acquires the necessary military technology which has been proven technically, without an unacceptably high degree of risk, on a fast timetable. Moreover, the recipient country can supplement its own development programs, and acquire spare parts and components easily. However, there are possible disadvantages in becoming a recipient of military technology: (Office of Industrial Innovation, 1986, p. 8)

1. The recipient could become locked into a particular technology,
2. The recipient may assume the obligation to purchase tied-in products, such as spare parts and associated elements while utilizing technology,
3. The recipient can be forced to accept restrictions in its marketing and policies relating to the licensed military technology, such as restrictions on export.

2. Supplier Country

There are several benefits to suppliers of military technology (Parker, 1974, p. 31). These include:

1. Maintaining reasonable, friendly relations with recipient nations,
2. Retaining a share of the market in recipient countries,
3. Decreasing the balance-of-payment deficits,

4. Establishing the recipient country as a market for both the supplier's spare parts and maintenance services for the transferred technology and, finally,

5. Permitting the supplier to acquire a part-interest in the recipient company in return for supplying the technology, such as in a joint venture.

On the other hand, the recipient country could become a competitor and threaten the lead of the supplier's technology. Therefore, the supplier may choose not to supply its military technology. Moreover, the supplier country also has to worry that technology supplied to unstable regimes may someday fall into the hands of hostile forces. Finally, the growing arms production in the developing countries will reduce the supplier's control over some of its more ambitious and independent-minded clients.

VI. CONCLUSIONS AND RECOMMENDATIONS

The ultimate objective of Turkish defense policy is to achieve self-sufficiency in arms production to assert national independence. However, there are two major reasons why achieving total self-sufficiency in arms production in Turkey is very difficult. First, military technology develops so fast that the limited resources do not allow outlays on research and development to keep up with it. Second, producing everything related to all military systems often is not possible or not feasible within the resource constraints.

Success in developing and producing defense systems relies heavily on the industrial capability, human capital and technological base. As Table 4 shows, Turkey has more defense production capacity than she has been using. Therefore, there are some slack resources which have not been used in the arms production process such as the private sector ability. On the other hand, Turkey has enough technological base only to assemble some of the

weapon systems and production of basic components designed abroad.

In order to produce major weapon systems to satisfy the needs of the Turkish Armed Forces and export purposes, Turkey has to transfer military technology from abroad.

The following projects have been selected to fulfill the needs of the Turkish Armed Forces to create an adequate technological base in the arms production and for export military hardware:

1. F-16 C/D combat aircraft
2. Light cross-country vehicles
3. Low altitude air defense system
4. Stringer and Maverick missile
5. Multiple-launch rocket systems
6. Armored combat vehicles
7. Transportation aircraft and helicopters

If the prescribed path strategy of military technology transfer for total self-sufficiency in arms production is followed, it is very likely that the efforts moving from licensed to indigenous production will fail. There is no developing country which has achieved the total self-sufficiency in arms production. For example, Argentina in

the 1950s and Egypt in the 1960s failed in moving from licensed production to indigenous arms production. Israel, India and Brazil have been more successful, but they are dependent on foreign military technology in terms of blueprints and components.

Turkey first has to create an efficient military technological base and reduce the technological gap by utilizing licensing, coproduction, joint venture and foreign design assistance as channels of technology transfer. Depending on terms and conditions negotiated within each channel, joint ventures may be better than other transfer forms, because technology suppliers share the risks of the weapons production.

Policy makers in Turkey have agreed that joint venture with economic offsets would allow for an expansion of the domestic arms production. Also this will facilitate the transfer of military technology to Turkey and enhance Turkey's status in the international arms market.

The key requirement of joint venture, coproduction and licensing agreements should be a provision that permits export sales of the military product to third parties. In addition, arms production agreements should require that

the foreign investor be the minority shareholder in any joint venture with a Turkish firm. For instance, one-third participation by government capital, one-third by the foreign firm, and one-third by Turkish private enterprise may be put into implementation as a policy.

Turkey has limited research and development capacity and relatively dependent industrial sector. Therefore, instead of having a desire to become self-sufficient in a broad range of equipment, Turkey should be specializing in military products in which she can develop a competitive advantage.

After acquiring a certain level of military technology and experience in production of weapon systems, Turkey then should apply engineering strategies in the indigenous arms production. Because, developing new technology is very costly. Furthermore, technologically sophisticated products rapidly become obsolete, forcing the producers to modify and improve on a continuous basis.

One of the engineering strategies that Turkey may follow is "add-on engineering". Application of this strategy will start with existing weapon technology which is first transferred and then produced under license or

other means. The designs may then be studied, modified, and adopted to the requirements of the Turkish Armed Forces. In this strategy, efforts are put at updating and improving the existing military technology rather than investing scarce resources into the development of new designs.

The second strategy that Turkey may follow is "add-up engineering". The Turkish defense industry may put together components available from any outside sources to a system not available elsewhere. Therefore, the basic source of technology is not one specific system. This strategy requires the availability of the major components and more technical capability than add-on *engineering*.

Turkey would not sustain a domestic defense industry without arms exports. However, exports of weapons can only be achieved in the international market if the domestic arms production is efficient, if its product is of good quality, is simple, and it's prices are competitive.

APPENDIX A

MILITARY CRITICAL TECHNOLOGIES LIST

1.0	COMPUTER NETWORKS TECHNOLOGY
1.1	Network Architecture
1.2	Implementation Technologies
2.0	COMPUTER TECHNOLOGY
2.1	System Architecture Technology
2.1.1	General System Architecture Technology
2.1.2	Processor Architecture Technology
2.1.3	Memory Hierarchy Technology
2.2	Systems Hardware Development and Production Technology
2.2.1	Computer Hardware Development Technology
2.2.3	Computer Manufacturing Control System (CMCS) and Computer Assisted Manufacturing (CAM) Technology
2.2.4	Interconnections Technology
2.2.5	Production Test Technology
2.2.6	Computer Cooling Technology
2.2.7	Power Supply and Distribution
2.3	Digital Computer System Utilization Technology
2.3.1	Computer-Assisted Servicing (CAS) Technology
2.3.2	Computer System Configuration Management Technology
2.3.3	Digital Computer Security Technology
2.3.4	Computer-Assisted Training/Simulation Technology
2.4	Logic and High-Speed Memory Assembly Technology
2.4.1	Semiconductor Logic and Memory Assembly Technology
2.4.2	Magnetic Core Memory Technology
2.4.3	Josephson Junction Technology
2.4.4	Charge-Coupled Device (CCD) Memory Technology
2.4.5	Magnetic Bubble Logic and Memory Technology
2.4.6	Magnetic Cross-Tie Memory Technology
2.4.7	Plated-Wire Memory Technology
2.4.8	Microprocessor Technology
2.5	Storage Technology

2.5.1 Magnetic Disc Storage
2.5.1.1 Magnetic Disc Read/Write Head Technology
2.5.1.2 Magnetic Disc Recording Media Technology
2.5.1.3 Winchester Disc Technology
2.5.1.4 Flexible Disc Drive Technology
2.5.2 Magnetic Tape Storage Technology
2.5.2.1 Conventional Magnetic Tape Drive Technology
2.5.2.2 Cartridge/Cassette Technology
2.5.3 Other Storage Technology
2.5.3.1 Electron Beam Memory
2.5.3.2 Optical Cryogenic Memory Technology
2.5.3.3 Holographic/Laser Memory Technology
2.5.3.4 Video Disc Digital Recording Technology
2.5.3.5 Archival Magnetic Tape Memory Technology
2.6 Digital Computer Display and Peripheral Technology
2.6.1 Alphanumeric and Graphic Terminal Technology
2.6.2 Peripheral Technology
2.6.2.1 Digital Flat-Bed Technology
2.6.2.2 Nonimpact Line Printer Technology
2.7 Analog and Hybrid Computer
2.8 Other Related Technology
2.8.1 Speech Processing Technology
2.8.2 Artificial Intelligence Technology

3.0 SOFTWARE TECHNOLOGY

3.1 Development Environment Technology
3.1.1 Software Life-Cycle Management Technology
3.1.2 Software Library Data Base
3.1.3 Software Development Tool Technology
3.1.4 Formal Methods and Tools for Developing Trusted Software Technology
3.2 Operations and Maintenance
3.2.1 Maintenance of Large Software Product Technology
3.3 Application Software Technology
3.3.1 Secure Software Technology
3.3.2 Large Self-Adapting Software System Technology

4.0 AUTOMATED REAL-TIME CONTROL TECHNOLOGY

4.1 Utilization of Digital Processing Technology
4.2 Analog and Hybrid Computing Technique Technology
4.3 Display Technology
4.4 Related Software Technology

5.0 MATERIALS TECHNOLOGY

5.1	Metals and Alloys Technology
5.1.1	Magnetic and Amorphous Metals Technology
5.1.2	Nickel-Based Alloys Technology
5.1.3	Titanium Alloys Technology
5.1.4	High-Temperature Coatings Technology for Superalloys and Titanium
5.1.5	Niobium (Columbium) Alloys Technology
5.1.6	Molybdenum Alloys Technology
5.1.7	Tungsten Alloys Technology
5.1.8	Casting and Coating Technology of Intricate Hollow Superalloy Shapes
5.1.9	Plasma Spraying Technology
5.1.10	Advanced Powder Metallurgy Technology
5.1.11	Superplastic Forming/Diffusion Bonding (SPF/DB) Technology
5.1.12	Titanium, Nickel, and Iron Aluminides Technology
5.1.13	Superconducting Materials Technology
5.1.14	Pressure Pipe Fittings Technology
5.2	Advanced Composites Technology
5.2.1	Fibers and Filamentary Materials
5.2.2	Filament Winding, Tape Laying, and Interlacing Technology
5.2.3	Advanced Organic Matrix
5.2.4	Metal- and Graphic-Matrix Composites Technology
5.2.5	Ceramics Technology
5.2.8	Superalloy Composites Technology
5.3	Processing and Forming Technologies
5.3.1	Hot Isostatic Pressing (HIP) Technology
5.3.2	High-Temperature Press Technology
5.3.3	Isothermal Rolling Mill Technology
5.3.4	Isothermal Metal Working Technology
5.3.5	High-Temperature Furnace and Coating Unit Technology
5.3.6	Numerically Controlled Machine Tools Technology
5.3.7	Precision Turning Machines Technology
5.3.8	Spin- and Flow-Forming Machines Technology
5.3.9	High Vacuum Technology (Pumps)
5.3.10	Laser Processing Technology
5.3.11	High Performance Welding Technology
5.3.12	Fracture Analysis, Nondestructive Evaluation (NDE), and Control Technology
5.3.13	Test Equipment for Integrated Structural Testing Technology

6.0 DIRECTED ENERGY TECHNOLOGY

6.1 High Energy Laser (HEL Lasers) Technology
6.1.1 High Energy Laser Technology
6.1.2 Mirror and Optical Device Technology
6.1.3 Beam Pointing and Control Technology
6.1.4 Mounting Subsystem Technology
6.1.5 Beam-Targeting Coupling Technology
6.1.6 Beam Propagation Technology
6.2 Particle Beam Technology
6.2.1 High-Current Particle Beam Generation Technology
6.2.1.1 Post-Injection (Particle Beam Accelerator) Technology
6.2.2 Short-Term Energy Generation Subsystem Technology
6.2.3 Beam Propagation Technology
6.2.4 Beam-Target Coupling Technology
6.2.5 Beam Control Subsystem Technology
6.2.6 Beam Neutralization Technology
6.3 Microwave Energy Transmission Technology

7.0 SEMICONDUCTOR AND ELECTRONIC COMPONENT TECHNOLOGY

7.1 Microcircuit Technology
7.1.1 Wafer Preparation
7.1.2 Epitaxy
7.1.3 Oxidation
7.1.4 Maskmaking
7.1.5A Lithography-Resist Processing
7.1.5B Lithography-Wafer Imaging
7.1.6 Selective Removal
7.1.7 Diffusion/Implementation
7.1.8 Thin Film Deposition
7.1.9 Assembly
7.1.10 Testing
7.1.11 Facilities
7.1.12 IC Design
7.1.13 Hybrid Microcircuits
7.1.14 Microwave Microcircuits
7.2 Discrete Transistors
7.2.2 Diodes
7.2.3 Thyristors
7.3 Detector, Tube, Intensifier, and Cooler Technology
7.3.1 Semiconductor Detectors
7.3.2 Photomultiplier Tubes

7.3.3 Image Intensifiers
7.3.4 Thermoelectric Coolers
7.4 Acoustic Wave Device Technology
7.5 Thin Film Memory Device Technology
7.5.1 Magnetic Bubble Memories
7.5.2 Plated Wire Memories
7.5.3 Cross-Tie Memories
7.6 Passive Component Technology
7.6.1 Ferrite Materials
7.6.2 Boundary Layer Monolithic Ceramic Capacitors
7.6.3 Quartz Crystals
7.6.4 Printed Circuit Boards
7.7 Cryogenic Component Technology
7.7.1 Superconducting Digital Components
7.7.2 Superconducting RF Components
7.7.3 Cryogenic Coolers
7.8 Electronic Material Technology
7.8.1 Bulk Indium Phosphide (InP)
7.8.2 Bulk Gallium Arsenide (GaAs)
7.8.3 Vapor Phase Epitaxy of $In_{1x}Ga_xP_{1-y}As_x$ on InP
7.8.4 Lead Lanthamum Zirconium Titanate (PZLT)
7.8.5 Lead Zirconium Titanate ($Pb(Zr,Ti)O_x$, PZT)
7.8.6 MgO (Magnesium Oxide, Periclase)
7.8.7 Thin Film Interference Coatings for Optics and Other Applications by Vacuum Deposition
7.8.8 Sodium and Potassium Halides (NaF, NaCl, KCl, KBr etc)
7.8.9 Thallium Bromoidiode ($TIBr_x1_{1x}$, KRS-5)
7.8.10 Dehydrogen Phosphates (ADP, KDP, KD P, CD P, CD A, etc)
7.8.11 Bismuth Silicon Oxide (BSP, $Bi_{12}SiO_{20}$) Bismuth Germanium Oxide (BGO, $Bi_{12}GeO_{20}$)
7.8.12 Polyvalent Binary Fluorides (e.g., BaF_2 CeF_3 LaF_4 ThF_4 ZrF_4)
7.8.13 Yttrofluorides (e.g., $LiYF_4$, $KY_xF_{.0}$, etc)
7.8.14 Niobates and Tantalates (e.g., $LiNbO_3$, $LiTaO_3$ $KNbO_3$)
7.8.15 Neodymium Laser Hosts (especially YAG (Y Al ..), but also including $La_2Be_2O_3$, NdP_3O_{14} $K_4NdLi_xF_{10}$, etc)
7.8.16 Lanthanum Chloride Laser Materials ($LaCl_3$: Pr^{3+}, Er^{3+} etc)
7.8.17 Mercury Cadmium Telluride (bulk and thin films)
7.8.18 Cadmium Telluride Crystals
7.8.19 Lead Telluride (PbTe)

7.8.20 Ipitaxial Lead Tin Telluride and Lead Telluride (PbSnTe and PbTe)
7.8.21 Lead Tin Selenide ($Pb_{1x}SN_xSe$)
7.8.22 Electroptical Materials with the Chalcopywrite Structure
7.8.23 Rate Earth-Transition Metal Permanent Magnets (example: samarium cobalt and substituted samarium cobalt)
7.8.24 Galdolinium Gallium Garnet (GGG) and Substituted GGG as a Substrate for Magnetic Oxide Films (see also Section 7.5)
7.8.25 Materials for Magnetic Bubble Memories (Thin Magnetic Films Grown on Subsrates)
7.8.26 Germanium-High Purity Detector Grade
7.8.27 3" or Greater Diameter Silicon Wafers
7.8.28 Detector Grade Silicon Wafer with Resistivity 10,000-15,000 ohmcm
7.8.29 Indium Doped Extrinsic Silicon Crystals with Indium Concentration of about $10^{17}cm^{-3}$
7.8.30 Silicon on Sapphire (SOS)
7.8.31 Pyrolytic Boron Nitride (PBN)
7.8.32 Gallium Antimonide
7.8.33 Indium Arsenide
7.8.34 Indium Antimonide

8.0 INSTRUMENTATION TECHNOLOGY

8.1 Time-Domain Measurement Technology
8.1.1 Oscilloscope Technology
8.1.2 Time Interval Measurement Technology
8.2.1 Radio Spectrum Analyzer Technology
8.2.2 Panoramic and Digital Receiver Technology
8.2.3 Real-Time Spectrum Analyzer Technology
8.2.4 Frequency-Counter Technology
8.3 Frequency Standards and Signal Source Technology
8.3.1 Frequency Standard Technology
8.3.2 Frequency Synthesizer Technology
8.3.3 Signal Generator Technology
8.4 Electrical Parameter and Digital Measuring Technology
8.4.1 Network Analyzer Technology
8.4.2 Digital Volume Measuring Technology
8.4.3 Microwave Power Meter Technology
8.5 Digital Instrument Technology
8.5.1 Logic Analyzer Technology

8.5.2 Microprocessor Development System Technology
8.5.3 Analog-to-Digital and Digital-to-Analog Converter Technology
8.5.4 Automatic Test Equipment Technology
8.5.5 Digital Storage Oscilloscope and Digitizer Technology
8.6 Recording Technology
8.6.1 Recorder/Reproducer Technology
8.7 Photographic and Optical Measurement Technology
8.7.1 Photographic Interpretation Technology
8.7.2 Laser Rangefinding Technology
8.7.3 Laser Measurement Technology
8.7.4 LIDAR/Laser Radar Technology
8.7.5 Aerial and Streak Camera Technology
8.7.6 High Speed Cinema Recording Technology
8.7.7 Microdensitometer Technology

9.0 TELECOMMUNICATIONS TECHNOLOGY

9.1 Telecommunications Systems Technology
9.1.1 RF Communications Systems Technology
9.1.2 Optical Communications Technology
9.1.3 Acoustic Communications Systems Technology
9.1.4 Space Qualified Telecommunications Equipment Technology
9.2 Switching Technology
9.2.1 Circuit Switching Technology
9.2.2 Message Switching Technology
9.2.3 Packet Switching Technology
9.3 Modems and Multiplexing Technology
9.3.1 Modem technology
9.3.2 Multiplexing Technology

10.0 COMMUNICATION, NAVIGATION, GUIDANCE, AND CONTROL TECHNOLOGY

10.1 Vehicle Control Technology
10.1.1 Spacecraft Guidance and Control Technology
10.1.1.1 Spacecraft Stabilization Technology
10.1.1.2 Spacecraft Attitude Control
10.1.1.3 Spacecraft Techniques for Space Environmental Effects
10.1.1.4 Satellite Thermal Design Technology
10.1.5 Onboard Sensor Techniques Providing Control Information

10.1.2 Air Vehicle Guidance and Control Technology
10.1.2.1 Remote Control Techniques
10.1.3 Ship Guidance and Control Technology
10.1.3.1 Navigation and Positioning Techniques
10.1.3.2 Techniques for In-Water Speed Measurement and Integration
10.1.4 Submersible Guidance and Control Technology
10.2 Inertial Navigation Systems (INS) and Related Technology
10.2.1 Inertial Navigation Systems Integration Technology
10.2.2 Inertial Gimballed Platform Technology
10.2.3 Inertial Strapdown Systems Technology
10.2.4 Floated Ball-Bearing Gyroscope Technology
10.2.5 Gas Bearing Gyroscope Technology
10.2.6 Flexure Rotor Gyroscope Technology
10.2.7 Ring Laser Gyroscope Technology
10.2.8 Electrostatically Supported Gyroscope Technology
10.2.9 Nuclear Magnetic Resonance Gyroscope Technology
10.2.10 Fiber Optics Gyroscope Technology
10.2.11 Low-Cost Gyroscope Technology
10.2.12 Accelerometer Technology
10.2.13 Autopilot Technology
10.2.14 Test, Calibration and Alignment Technology
10.3 Cooperative Systems for Radio Navigation and Radio Communication Technology
10.3.1 Techniques for Platform Cooperative Radio-Navigation and Radio Direction Finding
10.3.1.1 Radio Signal Conversion Technology
10.3.1.2 Radio Signal Detection and Processing Technology
10.3.1.3 Navigation Computation and Control Technology
10.3.1.4 Systems Integration Technology
10.3.2 Platform Cooperative Radio Communication Technology
10.3.2.1 Radio Signal-to-Noise Enhancement Technology
10.3.2.2 Antenna Matching Over a Multiplicity of User Allocated RF Band Technology
10.3.2.3 Radio Signal Transmitting, Receiving Detection, and Processing Technology
10.3.3 General Avionics/Electronics Systems Technology
10.3.3.1 Utilization of Solid-State Digital Components in System Design Technology
10.3.3.2 System Architecture Technology
10.3.3.3 Ruggedized/Hardened Equipment Technology

10.3.4 Display and Control Interface for Integrated Communication/Navigation Technology
10.3.4.1 Improved HUD--Holographic Combiner Lens Technology
10.3.4.2 Voice Control Input Technology

11.0 MICROWAVE TECHNOLOGY

11.1 Microwave Tube Technology
11.1.1 Electron Gun and Beam Design
11.1.2 Microwave Circuits
11.1.3 Microwave Tube Assembly
11.2 Microwave Solid-State Device Technology
11.3 High Power Microwave Control Component Technology
11.4 Waveguide and Component Technology

12.0 VEHICULAR TECHNOLOGY

12.1 Aeronautical Vehicle Technology
12.1.1 Laminar Flow Control (LFC)
12.1.2 Airfoil, Helicopter Rotor and Wing Designs (including high lift devices)
12.1.3 Computer-Aided Design and Manufacture (CAD/CAM)
12.1.4 Technologies for Integrating Sensor Subsystems
12.1.5 Control and Configured Vehicles
12.1.6 Flight Control and Flight Management
12.1.7 Electromagnetic Hardening Technology
12.1.8 High Contact Ratio, Double-Helical (Herribone) Gears
12.1.9 High Survivability (Loss of Lubrication) Technology
12.1.10 Advanced Propellers
12.1.11 Advanced Structural Bonding
12.2 Marine Vehicle Technology
12.2.1 Hydrodynamic Design of Advanced Hull Forms
12.2.2 Foil and Foil Structure Design for Advanced Hydrofoils
12.2.3 Lightweight Marine Platform Structure Technology
12.2.4 Technology for Flexible Curtains and Skirts for Air Bubble Supported Platforms
12.2.5 Automated Platform Controls for Hydrofoils and Other High-Speed Marine Vehicles
12.2.6 Polymer Injection Technology for Drag Reduction
12.3 Deep Submergence Vehicle Technology
12.3.1 Manned Submersibles, Untethered

12.3.2 Manned Submersibles, Tethered and Diving Equipment
12.3.3 Unmanned, Tethered and Towed Submersibles
12.3.4 Unmanned, Untethered Vehicles
12.3.5 Syntactic Foam Technology
12.4 Gas Turbine Propulsion for Aeronautical Vehicle Technology
12.4.1 System Configuration, Aerodynamic and Thermodynamic Analysis
12.4.2 Variable Flowpath Technology
12.4.3 Centrifugal Flow Compressor Aerodynamics
12.4.4 Axial Flow Fan and Compressor Aerodynamics
12.4.5 Turbine Technology
12.4.6 Cooler Turbine Technology
12.4.7 Rotating Propulsion System Structures
12.4.8 High DN Rolling Element Bearings
12.4.9 Gas Film Bearing Design
12.4.10 Ceramic Hybrid Bearing Design
12.4.11 Gaspath Sealing Technology
12.4.12 Gaspath Sealing Technology
12.4.13 Coating Technology
12.4.14 Combustor Aerodynamics
12.4.15 Combustion System Structures
12.4.16 Afterburner/Ductburner Aerothermodynamics
12.4.17 Frames, Duct, and Cases
12.4.18 Propulsion System Integration Technology
12.4.19 Electronic Control Technology and Diagnostics
12.4.20 Sensors, Actuators, Interfaces, and Interconnections for Advanced Engine Control Systems
12.4.21 Fuel Pumps
12.4.22 Electrical Power Generation
12.4.23 Inlet Technology
12.4.24 Nozzles, Thrust Vectoring, and Thrust Reversing Technology
12.4.25 Wind Tunnel and Propulsion Test Cell Technology
12.5 Gas Turbine Propulsion for Marine Vehicle Technology
12.5.1 Gas Turbine Engine Moisture and Particulate Separator Systems
12.5.2 Protective Coating Technology for Marine Gas Turbine Engines
12.5.3 Technology for Heavy Fuel Capability for Marine Gas Turbine Engines
12.5.4 High Temperature Heat Exchanger Technology

14.2	Passive X-Ray Sensor Technology
14.3	Conventional Acoustic Sensor Technology
14.4	Fiber Optic Sensor System Technology
14.5	Magnetometer and Magnetic Sensor Technology
14.6	Gravity Meter Technology
14.7	Radar and Related Technology
14.7.1	Systems Architecture, Design and Integration Technology
14.7.2	Transmitter Technology
14.7.3	Advance Radar Antenna Design Technology
14.7.4	Radar Receiver Technology
14.7.5	Signal Processing Technology
14.7.6	Display Technology
14.7.7	Radar Absorbing Material Technology
15.0	UNDERSEA SYSTEMS TECHNOLOGY
15.1	Undersea Acoustic Technology
15.1.1	Acoustic Propagation, Modeling, and Forecasting Technology
15.1.2	Acoustic Reception Technology
15.1.3	Acoustic Transmission Technology
15.1.4	Acoustic Display Technology
15.2	Platform Acoustic Technology
15.3	Heavy Lift Salvage Technology
15.4	Deep Sea Sensor Implantation Technology
15.5	Research Facility Technology
16.0	CHEMICAL TECHNOLOGY
16.1	Polymeric Material Technology
16.2	Hydraulic Fluid Technology
16.3	Synthetic Lubricating Oil and Grease Technology
16.4	Synthetic Elastomer Technology
16.5	Atmospheric Purification Technology

Source: U.S. Department of Defense, *The Military Critical Technologies List*, Office of the Under Secretary of Defense, Acquisition, October 1986.

APPENDIX B

TYPES OF OFFSETS

Coproduction: Agreements between governments that permit a foreign government or producer to acquire the technical information to manufacture all or part of a U.S. defense article overseas. It includes government to government licensed production.

Licensed Production: Overseas production of U.S. origin defense articles based upon the transfer of technical information under direct commercial arrangements between a U.S. manufacturer and a foreign government or producer.

Subcontractor Production: Overseas production of a part or component of a U.S. origin defense article. The subcontract does not necessarily include license of technical information. This type of production is usually a direct commercial arrangement between a U.S. manufacturer and a foreign producer, and often takes the form of a joint venture or subsidiary

Overseas Investment: Investment arising from the offset agreement, taking the form of capital invested to establish or expand a subsidiary or joint venture in the foreign land.

Technology Transfer: Transfer of technology that occurs as a result of an offset agreement (other than coproduction and licensed production) that may take the form of research and development conducted in the buyer country, technical assistance provided to the subsidiary or joint venture, or other activities under direct commercial arrangements between the U.S. manufacturer and the foreign entity.

Countertrade: The term is used here to describe all agreements including the reciprocal purchase of civil or defense goods and services from the foreign entity as a condition of sale of military related exports. The principals in those arrangements usually are a firm in a

developed country and a foreign government or company. Countertrade agreements take the same general form in civilian and military sectors.

Barter: A one-time transaction bound under a single contract that specifies the exchange of selected goods or services of equivalent value without the use of currencies. Barter is used in the international arms trade. In these arrangements, money may be exchanged, but the seller, under separate contract, agrees either to buy a product from the customer or find an export market for his product.

Counter purchase: An agreement by the initial exporter to buy, or find a buyer for, a specified value of unrelated goods from the original importer during a specified time period. In this form of reciprocal trade, a company sells military equipment or services to another country for cash plus products.

Compensation: An agreement by the original exporter to accept, as full or partial repayment, goods derived from the original exported product, such as electronic components produced from a certain machine. Agreements for repayment in related goods are often referred to as "buy-backs".

Switch: Switch trading occurs when one party to a countertrade agreement (usually the original seller) cannot use or sell goods contracted for. Purchase options for the goods are sold by the original buyer at a discount to specialists known as switch traders to dispose of the goods on the international market.

Source: U.S. General Accounting Office, **Military Exports: Analysis of Interagency Study on Trade Offsets**, GAO/NSIAD-86-99-BR, April 1986, Appendix II.

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